Mines and Minerals Division

Ontario Geological Survey
Report 248

Geology of the
Garnet Lake Area
District of Sudbury

by
G.M. Siragusa

1987

Ontario
Ministry of
Northern Development
and Mines

©Queen's Printer for Ontario, 1987
ISSN 0704-2582
Printed in Ontario, Canada
ISBN 0-7729-0410-3

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Canadian Cataloguing in Publication Data

Siragusa, G. M.

Geology of the Garnet Lake area, district of Sudbury

(Ontario Geological Survey report, ISSN 0704-2582 ; 248)
Spine Title: Garnet Lake area.
Includes index.
ISBN 0-7729-0410-3

1. Geology--Ontario--Garnet Lake Region. I. Ontario. Ministry of Northern Development and Mines. II. Ontario Geological Survey. III. Title. IV. Title: Garnet Lake area. V. Series.
QE191.S57 1987 557.13'133 C86-099656-5

Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Northern Development and Mines does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

Parts of this publication may be quoted if credit is given. It is recommended that reference be made in the following form:

Siragusa, G.M.
1987: Geology of the Garnet Lake Area, District of Sudbury; Ontario Geological Survey, Report 248, 81p. Accompanied by Maps 2503 and 2504, scale 1:31 680.

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Critical Reader: N.F. Trowell
Editor: E.F. Moorhouse
1000-87-U of T Press

Foreword

93-00440/

A detailed mapping project was initiated in the Garnet Lake area in 1977 and 1978 by the Ontario Geological Survey, Ministry of Natural Resources.

This project was the first phase of a long-range program to provide up-to-date mapping of the Swayze part of the Abitibi Subprovince and information on known gold and base metal occurrences.

This project has served to provide a more effective data base for determining the mineral potential of this region with specific emphasis on guides to exploration of the known gold and base metal occurrences of the Garnet Lake Area.

V.G. Milne

Director

Ontario Geological Survey

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GEOLOGICAL MAPS (back pocket)

Map 2503 (coloured)—Cunningham and Garnet Townships, District of Sudbury.

Scale 1:31 680.

Map 2504 (coloured)—Benton and Mallard Townships, District of Sudbury.

Scale 1:31 680.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

Geology of the
Garnet Lake Area
District of Sudbury

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Manuscript approved for publication by the Chief Geologist, March 1981. This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

The dominant rocks in the Cunningham-Mallard Townships area are metamorphosed flows of magnesium and iron-rich tholeiitic basalt which are of Archean age. They trend northwest, dip subvertically to steeply to the southwest, and extend beyond the boundaries of the area. They were metamorphosed essentially to the greenschist rank. They contain subordinate volumes of calc-alkaline and dominantly pyroclastic metavolcanics, and are part of the southwestern limb of the westward trending Woman River Anticline (Goodwin 1965) the core of which is exposed in Heenan and Marion Townships, adjacent to the northern boundary of the present map area. The calc-alkaline metavolcanics underlie large parts of southern Mallard and central Benton Townships, but do not appear to extend significantly into the western half of the map area.

Broadly concordant intrusions of gabbroic rocks, which are regarded as formerly horizontal or subhorizontal intravolcanic sills of the same age as the metavolcanics within which they occur, underlie relatively large parts of Cunningham, Garnet, and Mallard Townships. A few small intrusions of peridotite are found mostly in Cunningham Township.

Metasediments consisting of volcanogenic conglomerate and of chert-magnetite ironstone, are locally interbedded with the metavolcanics mostly in the western half of the map area. Significant concentrations of base metal sulphides are locally found within the cherty units; at one locality of central Cunningham Township a deposit of about 1,000,000 tons containing 1.28 percent zinc and 1.2 percent copper has been indicated.

Regional granitic rocks of leucocratic and potassic character underlie the northeastern part of Mallard Township, and a pluton of similar rocks underlies part of southwestern Cunningham Township. This pluton is surrounded by supracrustal rocks, gabbro, and peridotite, and is bisected by a prominent fault trending north-northwest. Minor lithologic types include rare dikes of diabase, lamprophyre, and syenite, of Late Precambrian age.

In general, proximity to contacts with gabbroic or dioritic intrusions appears to have been regarded as a favourable condition for the occurrence of base metal sulphide minerals in the cherty units of the map area, and some field evidence seen by the writer does indeed suggest that the emplacement of the intrusive rocks has locally resulted in concentration of sulphides close to the chert-intrusion contact. Nevertheless, in the writer's opinion, the presence of mafic intrusive rocks, and particularly of large volumes of them, is in itself a negative factor inasmuch as these rocks tend to disrupt or truncate the cherty units which host the base metals. It is felt that the cherty units should be prospected for base metals regardless of their closeness to mafic intrusive rocks, and that the units found in the Yarwood Lake area of northeastern Cunningham and northwestern Garnet Townships may deserve more attention than they have received thus far.

Garnet Lake Area, District of Sudbury, by G.M. Siragusa, Ontario Geological Survey Report 248, 81p. Accompanied by Maps 2503 and 2504, scale 1:31 680. Published 1987, ISBN 0-7729-0410-3.

Résumé

Les roches dominantes de la région des cantons de Cunningham-Mallard sont des coulées métamorphisées de magnésium et de basalt tholéiitique riche en fer datant de l'ère archéenne. Elles sont orientées vers le nord-ouest, plongent subverticalement à abruptement vers le sud-ouest, et s'étendent au-delà des limites de la région. Elles ont atteint le plus souvent le degré de métamorphisation du schiste vert. Elles contiennent de moindres volumes de roches volcaniques calcaires-alcalines et surtout métavolcaniques pyroclastiques, et font partie du flanc sud-ouest de l'anticlinal de la rivière Woman orienté vers l'ouest (Goodwin 1965), dont le coeur est exposé dans les cantons de Heenan et de Marion, et adjacent à la limite nord de la région indiquée sur la carte. Les roches métavolcaniques calcaires-alcalines sont sous-jacentes à de vastes sections du sud du canton de Mallard et du centre du canton de Benton, mais ne semblent pas s'étendre considérablement dans la moitié ouest de la région indiquée sur la carte.

Des intrusions de roches gabbroïques généralement concordantes, que l'on pense être d'anciens filons-couches horizontaux et sub-horizontaux de la même époque que les roches métavolcaniques dans lesquelles elles apparaissent, sont sous-jacentes à des sections assez étendues des cantons de Cunningham, Garnet, et Mallard. C'est surtout dans le canton de Cunningham que l'on trouve quelques petites intrusions de péridotite.

Les roches métasédimentaires composées de conglomérat volcanogénique et de minerai de fer constitué de chert et de magnétite, alternent localement avec les roches métavolcaniques, surtout dans la moitié ouest de la région indiquée sur la carte. On a trouvé dans la région de considérables concentrations de sulfures de métal commun dans les unités siliceuses; on a décelé dans une localité située au centre du canton de Cunningham un dépôt de près de 1 000 000 de tonnes contenant 1,28 pour 100 de zinc et 1,2 pour 100 de cuivre.

Des roches granitiques régionales de caractère leucocratique et potassique sont sous-jacentes à la section nord-est du canton de Mallard, tandis qu'un pluton de roches semblables est sous-jacent à une partie du sud-ouest du canton de Cunningham. Ce pluton est entouré de roches affleurant à la surface de l'écorce terrestre, gabbro et péridotite, et est coupé en deux par une importante faille orientée vers le nord-nord-ouest. Certains types lithologiques mineurs comprennent de rares filons de diabase, de lampophyre et de syénite datant de la fin de l'ère précambrienne.

En général, la proximité des contacts avec les intrusions gabbroïques et dioritiques semble avoir été considérée comme une condition favorable à l'apparition de minéraux de sulfure de métal commun dans les unités siliceuses de la région indiquée sur la carte. Certains indices géologiques décelés par l'auteur suggèrent en effet que l'emplacement des roches intrusives a entraîné localement une concentration de sulfures proche de la zone de contact avec l'intrusion siliceuse. Quoi qu'il en soit, l'auteur est d'avis que la présence de roches intrusives mafiques, notamment lorsqu'elles sont en grand nombre, constitue en soi un facteur négatif dans la mesure où ces roches ont tendance à désintégrer ou émousser les unités siliceuses qui abritent les métaux communs. On pense que les unités siliceuses devraient faire l'objet de prospection des métaux communs indépendamment de la proximité des roches intrusives mafiques, et que les unités découvertes dans la région du lac Yarwood au nord-est du canton de Cunningham et au nord-ouest de celui de Garnet méritent probablement plus d'attention qu'elles n'en ont reçue jusqu'à présent.

Introduction

Location and Access

The Garnet Lake area is bounded by Latitudes 47°40′ and 47°45′30″N and by Longitudes 82°13′ and 82°44′W Longitudes. The area includes the 4 contiguous townships of Cunningham, Garnet, Benton, and Mallard for a total of approximately 369 km². A bush road connects eastern Garnet Township with Sultan via a gravel road formerly owned by Eddy Forest Products Limited; this road connects Highways 129 and 144 and was opened to the public in 1978. The distance from the bridge on the Wakami River in east-central Garnet Township to Sultan is about 43 km, and the distance of Sultan from Chapleau is about 67 km. Another bush road connects the southwestern tip of Rush Lake in northeastern Mallard Township with the former private road just mentioned, and the distance from Rush Lake to Chapleau is about 139 km. Garnet, Travel, and Yarwood Lakes, and the deep northwest-trending segment of the Wakami River west of the bridge are also good access points to Garnet Township by float-equipped bush plane. Ransom and Peter Lakes, and, under favourable wind conditions, Santimaw, Kostka, Allen, and Mink Lakes, are useful for the same purpose in Cunningham Township, and Opeepeesway and Rush Lakes in Mallard Township. The Wakami, Woman, and Opeepeesway Rivers offer good canoe routes within the map area and were constantly used as base lines for traversing.

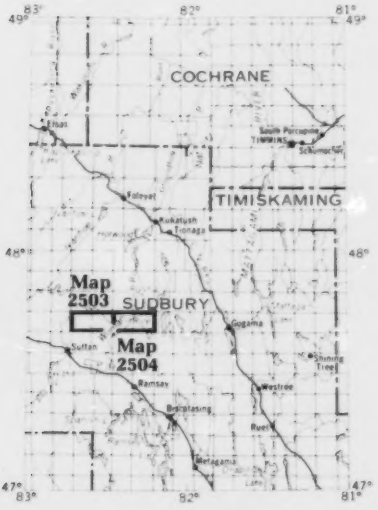

Figure 1. *Key map of the Garnet Lake Area. Scale 1:3 168 000.*

Physiography

The map area is characterized by flat to gently rolling physiography with elevations that are mostly between 380 and 396 m above sea level at the valley bottoms and the surfaces of the main lakes, and between 411 and 427 m at the hilltops. The eastern peak of a small northwestward trending ironstone ridge in central Cunningham Township has the maximum elevation of 503 m above sea level. Terrain with elevation equal to, or greater than 411 m above sea level is typical of a) parts of central, southern, and northeastern Cunningham Township which together account for about two thirds of the area of the township, b) the northwestern and southwestern corners of Garnet Township, and c) a northward trending narrow zone of Mallard Township east of the Opeepeesway River. Apart from the parts of the map area just mentioned, the areal extent of terrain with an elevation of 411 m or more is very minor in most of Garnet and western Mallard Townships, and in the whole area of Benton Township. Extensive swamps which may include low-relief sand ridges or dunes covered by shrubby vegetation and/or forest, are typical landforms particularly in the eastern half of the map area, and are the dominant physiographic feature in Benton Township.

The map area is within the Arctic watershed and is drained by the Wakami, Woman, and Opeepeesway Rivers. The Wakami River receives the waters of Ridout Lake (western Cunningham Township), flows eastward into Ransom Lake, thence flows outside and to the north of the map area where it collects the drainage of Swayze and Dore Townships. From Dore Township the river flows to the southeast, enters again the map area in northern Garnet Township, and at the boundary of Garnet and Benton Townships changes its course from southeast to east-northeast. The Wakami River ends in east-central Benton Township where it joins the Woman River which flows to the northeast upstream of the junction, thence flows eastward into western Mallard Township, and from here flows to the northwest outside the map area. The Opeepeesway River crosses Mallard Township along an essentially northerly course, flows northward, and joins the Woman River in southwestern Marion Township outside the map area. In northern Marion Township the Woman River receives also the overflow of Rush Lake via the Rush River, and thence drains northward into Horwood Lake.

Previous Work

Cunningham and Garnet Townships were mapped in 1941 by V.B. Meen (1944) at the scale of 1:63 360 (1 inch to 1 mile); Benton and Mallard Townships were mapped at the same scale in 1934 by H.C. Laird (1936).

Acknowledgments

In the summers of 1977 and 1978, S.A. Hasanie was the writer's senior assistant. F. Battika, K. Chalmers, and G. Stabb were the junior assistants during the summer of 1977, and G. Stabb and I. Fehrn were the junior assistants in the summer of 1978. B. Vinette worked also as junior for a few days at the beginning of the 1979 summer.

General Geology

Metamorphosed flows of magnesium-rich and iron-rich tholeiitic basalt are the dominant rocks in the map area, and form part of an Archean northwest-trending volcanic belt which extends beyond the western, southern, and northern boundaries of the area. The central section of the belt in the eastern half of the map area includes metamorphosed calc-alkaline flows, and calc-alkaline pyroclastic metavolcanics of intermediate composition which are particularly well exposed in southwestern Mallard Township, and extend to the southeast into northern parts of the Jerome area (Siragusa 1979). One outcrop of komatiite was located in southeastern Benton Township (*see* Figure 3). Narrow elongated units of porphyritic and/or pyroclastic rhyolite and dacite occur locally within the basaltic metavolcanics, or along strike of intermediate pyroclastic units. These felsic units represent a relatively minor part of the metavolcanics in the map area, and most of them occur in the boundary area of Benton and Garnet Townships. The metavolcanics were metamorphosed under conditions which seldom exceeded greenschist facies, but owing to deformation, the primary features of these rocks are too poorly preserved to be useful for top determinations. Structural data from southern localities of the map area, and from southern Heenan and Marion Townships (Goodwin 1965) suggest that they face southwest.

Relatively small units of epiclastic and chemical metasediments are locally interbedded with the metavolcanics, mostly in the western half of the map area. The former include a few units that are largely polymictic conglomerate, and the latter consist of laminated to medium-bedded chert interbedded with variable amounts of magnetite ironstone. The chert-ironstone units in Cunningham Township are locally the hosts of base metal sulphide mineralization in deposits of up to 1.1 million tons with 1.2 percent copper and 1.28 percent zinc (The Northern Miner 1975c).

Subvolcanic mafic intrusive rocks that are essentially of gabbroic composition underlie relatively large areas of Cunningham, Garnet, and Mallard Townships, and discrete small intrusions of peridotite occur mostly in Cunningham Township. Owing to scarcity of outcrops, the geological boundaries separating the gabbroic from the basaltic rocks are locally largely interpretive.

The granitic rocks are leucocratic and potassic in character, and include a few outcrops of regional granitic rocks poorly exposed in northeastern Mallard Township, and a faulted pluton surrounded by supracrustal and mafic intrusive rocks in southwestern Cunningham Township.

Minor lithologic types include a few dikes of Late Precambrian diabase, and rare dikelets of lamprophyre and syenite of uncertain age.

EARLY PRECAMBRIAN (ARCHEAN)

METAVOLCANICS

Mafic Metavolcanics

The metamorphosed mafic flows are essentially fine-grained foliated to sheared rocks of grey-green colour, which trend northwest to west-northwest, and dip subvertically or at steep angles to the north or south. The flows are locally pillowed and are seldom vesicular. Epidotic amygdules were noted at one locality of northern Cunningham Township, and varioles at another locality in the central part of the same township. Vesicular and porphyritic flows of calc-alkaline basalt (*see* Table 4, analysis 106) containing abundant plagioclase phenocrysts occur at one locality of east-central Garnet Township. Pillow breccia consisting of basaltic fragments up to 18 cm in size embedded in aphanitic basalt was seen at one locality of east-central Benton Township. Quartz veins and/or "pods" of variable size and irregular outlines may be found in these rocks. The quartz veins are commonly a few millimetres to about 20 cm in thickness, and up to 6 m in length. The mafic flows have undergone metamorphism which seldom exceeds greenschist rank and evidence of primary features, notably selvage margins of pillows, may be found even in sheared flows. Relatively unmetamorphosed pillows (Photo 1) tend to have lobate or irregular outlines which may locally reflect conditions of

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE GARNET LAKE AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT
Fluvial, lacustrine, and swamp deposits; sand, silt, and clay.

Unconformity

PRECAMBRIAN

MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)

MAFIC AND FELSIC INTRUSIVE ROCKS

MAFIC INTRUSIVE ROCKS
Diabase dikes, porphyritic diabase dikes, lamprophyre dikelets.

FELSIC INTRUSIVE ROCKS
Syenite dikelets.

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)

FELSIC INTRUSIVE AND METAMORPHIC ROCKS
Leucocratic potassic granitic rocks, migmatite

Intrusive Contact

METASEDIMENTS

EPICLASTIC METASEDIMENTS
Volcanogenic polymictic conglomerate, shale, argillite.

CHEMICAL METASEDIMENTS
Chert, magnetite ironstone.

SUBVOLCANIC INTRUSIVE ROCKS

MAFIC INTRUSIVE ROCKS
Gabbro, porphyritic gabbro, diorite.

ULTRAMAFIC INTRUSIVE ROCKS
Serpentinized and/or carbonatized peridotite

METAVOLCANICS
Fine- to medium-grained flows, pillowed flows, amygdaloidal flows, porphyritic flows, pillow breccia, intermediate pyroclastic rocks, felsic metavolcanics, ultramafic (komatiitic) flow.

Photo 1. *Relatively unmetamorphosed pillowed calc-alkaline basalt (analysis 132); the knife tip indicates the probable top direction. Wakami River, east-central Benton Township.*

near parallelism between the depositional plane of the flows and the present erosional surface, and, at any rate, rarely permit top determinations.

Because only one small outcrop of ultramafic komatiite was found in the map area, no ultramafic units of metavolcanics are shown on the maps. The outcrop of ultramafic komatiite is located in the southeastern corner of Benton Township to the south of, and very close to the inferred southern boundary of the main pyroclastic unit underlying the area (see Map 2504 in back pocket). The ultramafic komatiite is a rather soft aphanitic rock weathering to white hues which penetrate the rock for 4 or 5 mm. During mapping the rock was assumed to be ultramafic exclusively on account of these two features; the fresh cut of the rock has an indistinctive grey colour very similar to that most commonly seen in calc-alkaline basalt. A chemical analysis of this rock is shown in Table 3, analysis 249. A microscopic description is given in the section "Ultramafic Komatiite" under "Microscopic Description".

Intermediate Metavolcanics

These rocks include dominant pyroclastic and subordinate porphyritic types. The pyroclastic rocks consist of variably deformed clasts of dominant felsic metavolcanics, minor chert, and rare granitoid rocks, which are a few millimetres to over a metre in size, and are embedded in a fine-grained mafic matrix (Photo 2). The proportions of clasts of different size-classes within this dimensional range are variable, but apparently not as much as the ratio of total volume of clasts (regardless of size) to the volume of the rock (i.e. clasts plus matrix). The latter varies between the estimated minimum and maximum values of 0.1 and 0.7. A few matrix samples collected from pyroclastic units in such a way as to exclude any visible clasts, were chemically analyzed and found to be basalt (Table 4, analyses 114, 218), or andesite (Table 4, analysis 116). In most of the observed outcrops, and particularly in those of relatively large size, the clasts are apparently of dacitic to rhyolitic composition, and the matrix is basalt or andesite. In some outcrops,

TABLE 2. KEY TABLE TO FACILITATE LOCATION OF CHEMICAL ANALYSES ON MAP 2503 (CUNNINGHAM AND GARNET TOWNSHIPS) AND MAP 2504 (BENTON AND MALLARD TOWNSHIPS).

Analysis Number	Township Location
1 to 66	Cunningham
67 to 96	Benton
97 to 104	Mallard
105 to 107	Garnet
108 to 151	Benton
152 to 170	Mallard
171 to 172	Cunningham
173 to 174	Garnet
175 to 200	Benton
201 to 225	Mallard
226 to 249	Benton
250 to 258	Mallard

however, the clasts are essentially rhyolitic and the matrix is basalt. The range in silica content of the pyroclastic rocks can be estimated by simple calculations involving the proportions of clasts versus matrix, and statistical data obtainable from chemical analyses of many non-pyroclastic metavolcanics from the map area.

With clasts of dacitic to rhyolitic composition and matrix of basaltic to andesitic composition, the estimated silica content varies from 53.7 to 62.2 weight percent. This variation corresponds to a variation in clast content of 10 to 70 percent in volume. With rhyolitic clasts and basaltic matrix, the estimated silica content varies from 51.4 to 63.4 weight percent, for a variation in clast content as above. These figures suggest that the pyroclastic rocks may be generally regarded as "intermediate" in composition. However, in order to readily appreciate the effects of variations in the proportion and composition of clasts and matrix on the composition of the rock as a whole, each of the above ranges in silica content is compared with an independently derived range in silica content here referred to as the "intermediate range". The latter is defined as follows: the mean silica contents

TABLE 3. CHEMICAL ANALYSIS OF 1 SAMPLE OF ULTRAMAFIC KOMATIITE (WEIGHT PERCENT). Sample 249, Field Code 6-22-2

SiO_2	44.50
Al_2O_3	7.14
Fe_2O_3	1.80
FeO	10.20
MgO	20.80
CaO	8.02
Na_2O	0.00
K_2O	0.00
TiO_2	0.47
P_2O_5	0.06
S	<0.01
MnO	0.19
CO_2	0.29
H_2O^+	4.10
H_2O^-	0.70
Total	98.3

Sample number located on Geological Map 2504 (back pocket)

Photo 2. *Intermediate pyroclastic metavolcanics; the outcrop was wetted with water to emphasize the contrast between the felsic metavolcanic clasts and the mafic matrix. Southern Mallard Township.*

of basalt and rhyolite in the map area are 49.1 and 69.5 weight percent, respectively. Thus the silica content of an ideal intermediate rock is:

SiO_2 weight percent = 1/2 (49.2 + 69.5) = 59.35.

The lower and upper limits of the intermediate range are then given by:

(lower) SiO_2 weight percent = 1/2 (49.2 + 59.35) = 54.275 = 54

(upper) SiO_2 weight percent = 1/2 (59.35 + 69.5) = 64.425 = 64.

Comparison of the intermediate range, with the estimated range in silica content of rocks with dacitic to rhyolitic clasts and basaltic to andesitic matrix, indicates that most of these rocks are indeed of intermediate composition. Nevertheless, the minimum estimated silica content of these rocks is smaller than the lower limit of the intermediate range. In practical terms this means that rocks containing a volume of clasts of about 13 percent or less, are most likely mafic in composition. Similar conclusions apply to the comparison of the intermediate range with the estimated range in silica content of rocks with rhyolitic clasts and basaltic matrix. However, only rocks containing a volume of clasts greater than about 22 percent are truly intermediate in composition.

The intermediate pyroclastic rocks are best exposed in southwestern Mallard Township where they form a prominent northwestward trending unit which extends through Benton Township, and also to the southeast of the present map area (Siragusa 1979). Easily accessible exposures of this unit are found on the east side of the Rush Lake road, at the very southern boundary of Mallard Township. In southwestern Mallard Township the unit has a thickness of about 2400 m: owing to lack of outcrops in an extensive area to the northwest of this locality, the geological boundaries of this unit in Benton Township are largely interpretive. Some rhyolitic clasts seen in a few outcrops of this unit located in central Benton Township, are noted for their relatively angular outlines (Photo 3).

A unit of porphyritic calc-alkaline dacite (Table 4, analyses 128, 150, 151, 152, 162) is partially exposed along the Woman River east of the junction with the

TABLE 4. CHEMICAL ANALYSES OF 245 SAMPLES OF METAVOLCANICS AND 13 SAMPLES OF MAFIC INTRUSIVE ROCKS.

Field Code	3-3-50	3-3-51	3-3-52	3-3-53	3-3-54	3-3-55
Sample	1	2	3	4	5	6
SiO_2	44.3	50.1	47.0	50.7	46.4	44.3
Al_2O_3	16.2	15.1	15.2	15.6	15.4	15.6
Fe_2O_3	2.00	1.76	2.10	1.95	1.40	3.00
FeO	10.8	8.77	9.34	8.65	10.6	9.50
MgO	9.30	6.41	7.74	6.82	7.96	6.95
CaO	8.55	8.80	9.90	6.89	8.98	12.9
Na_2O	1.48	2.66	2.22	3.59	2.57	1.29
K_2O	0.38	0.32	0.24	0.28	0.17	0.05
TiO_2	1.02	0.91	0.90	0.96	0.93	0.93
P_2O_5	0.07	0.06	0.07	0.08	0.07	0.07
S	0.01	0.02	0.01	0.17	0.01	<0.01
MnO	0.22	0.20	0.20	0.18	0.21	0.22
CO_2	0.22	0.48	0.16	0.28	0.54	0.56
H_2O^+	4.03	2.47	2.65	2.88	3.16	2.64
H_2O^-	0.41	0.31	0.38	0.31	0.35	0.43
Total	99.0	98.4	98.1	99.4	98.7	98.4

Sample number located on Geological Maps (back pocket)
See Table 2 for township location

Field Code	3-3-56	3-3-57	3-3-58	3-3-59	3-3-60	3-3-61
Sample	7	8	9	10	11	12
SiO_2	47.3	44.0	50.1	49.9	47.4	47.0
Al_2O_3	15.3	15.2	12.4	14.9	15.7	15.0
Fe_2O_3	1.65	0.80	0.56	0.10	1.60	0.90
FeO	8.69	10.5	7.81	10.5	11.1	12.2
MgO	5.55	8.49	5.42	6.54	7.27	7.23
CaO	12.9	9.77	11.8	8.32	9.88	10.2
Na_2O	2.22	1.09	1.62	3.59	1.75	2.20
K_2O	0.09	0.05	0.01	0.01	0.07	0.01
TiO_2	0.97	1.02	0.69	0.98	1.01	0.92
P_2O_5	0.07	0.08	0.06	0.08	0.07	0.07
S	0.04	0.02	0.01	0.04	<0.01	0.02
MnO	0.19	0.20	0.16	0.21	0.22	0.23
CO_2	0.68	3.26	5.48	0.94	0.14	0.46
H_2O^+	2.21	5.04	3.40	2.91	2.87	2.83
H_2O^-	0.45	0.31	0.44	0.34	0.27	0.29
Total	98.3	99.8	100.0	99.4	99.4	99.6

TABLE 4 CONT'D.

Field Code	3-3-62	3-3-63	3-3-64	3-3-65	3-3-66	3-3-67
Sample	13	14	15	16	17	18
SiO_2	49.0	47.8	44.9	49.5	50.1	48.1
Al_2O_3	14.4	14.7	13.9	14.5	14.5	15.5
Fe_2O_3	0.90	1.00	0.01	1.70	0.90	0.70
FeO	11.3	11.2	12.2	10.4	11.2	10.6
MgO	6.71	6.61	6.78	6.90	7.52	6.19
CaO	10.2	10.5	9.53	11.0	8.90	10.2
Na_2O	2.53	2.21	1.82	1.09	1.59	2.85
K_2O	0.01	0.08	0.01	0.01	0.01	0.08
TiO_2	0.85	0.87	0.86	0.86	0.89	0.84
P_2O_5	0.08	0.06	0.07	0.08	0.08	0.07
S	0.02	<0.01	<0.01	0.03	0.01	0.04
MnO	0.23	0.22	0.22	0.21	0.18	0.22
CO_2	0.42	0.92	5.24	0.52	0.20	1.36
H_2O^+	2.29	2.49	4.79	2.52	3.05	2.22
H_2O^-	0.20	0.36	0.37	0.38	0.35	0.40
Total	99.1	99.0	100.7	99.7	99.5	99.4

Field Code	3-3-68	3-3-69	3-3-70	3-3-71	3-3-72	3-3-73
Sample	19	20	21	22	23	24
SiO_2	46.8	45.4	46.2	46.2	45.7	47.2
Al_2O_3	15.7	15.3	16.2	16.3	15.3	15.0
Fe_2O_3	1.40	1.50	0.80	2.30	1.70	1.30
FeO	11.4	13.8	11.2	10.5	9.82	10.1
MgO	4.52	3.53	8.01	7.14	7.02	8.62
CaO	11.1	8.96	9.36	11.5	7.81	8.88
Na_2O	0.94	2.95	2.45	2.38	2.66	2.20
K_2O	0.08	0.05	0.48	0.13	0.07	0.19
TiO_2	1.15	1.17	0.90	0.88	0.85	0.84
P_2O_5	0.10	0.09	0.07	0.07	0.06	0.06
S	0.25	0.10	0.02	0.05	0.07	0.02
MnO	0.29	0.29	0.23	0.22	0.21	0.20
CO_2	1.96	2.96	0.30	0.38	4.88	1.40
H_2O^+	3.30	2.38	2.55	2.18	4.76	3.24
H_2O^-	0.36	0.39	0.41	0.28	0.48	0.32
Total	99.3	98.9	99.2	100.5	101.4	99.6

TABLE 4 CONT'D.

Field Code	3-3-74	3-3-75	3-3-76	3-3-77	3-3-78	3-3-79
Sample	25	26	27	28	29	30
SiO_2	47.7	47.6	50.6	48.2	46.3	47.7
Al_2O_2	15.3	14.1	14.7	14.0	14.3	14.6
Fe_2O_3	2.00	2.20	1.30	2.40	3.10	2.30
FeO	9.10	9.90	9.26	11.7	12.2	12.6
MgO	7.71	7.20	4.27	4.52	5.48	4.24
CaO	11.0	10.4	8.43	9.56	10.7	8.71
Na_2O	2.52	1.89	3.72	2.14	1.39	2.65
K_2O	0.01	0.01	0.07	0.26	0.01	0.21
TiO_2	0.83	0.83	0.82	1.04	1.13	1.09
P_2O_5	0.06	0.07	0.05	0.08	0.10	0.09
S	0.03	0.07	0.02	0.02	0.02	0.10
MnO	0.20	0.19	0.27	0.26	0.22	0.25
CO_2	0.56	2.48	3.44	2.58	0.64	1.44
H_2O^+	1.99	3.14	2.80	3.08	2.66	2.52
H_2O^-	0.38	0.33	0.31	0.26	0.31	0.25
Total	99.4	100.4	100.1	100.1	98.6	98.7
Field Code	**3-3-80**	**3-3-81**	**3-3-82**	**3-3-83**	**3-3-84**	**3-3-85**
Sample	**31**	**32**	**33**	**34**	**35**	**36**
SiO_2	45.4	49.5	49.5	48.8	47.3	49.3
Al_2O_3	16.6	14.8	14.7	14.8	15.4	16.3
Fe_2O_3	2.40	1.60	1.50	1.20	1.70	1.60
FeO	10.4	9.34	9.50	9.82	11.0	9.98
MgO	7.21	8.40	8.39	8.50	6.62	6.33
CaO	8.44	9.70	11.4	9.82	9.35	9.20
Na_2O	2.35	2.86	1.45	2.41	3.21	2.85
K_2O	0.20	0.34	0.13	0.27	0.01	0.03
TiO_2	0.92	0.73	0.70	0.72	0.94	0.97
P_2O_5	0.06	0.05	0.06	0.06	0.07	0.08
S	0.02	0.05	0.06	0.02	0.07	0.02
MnO	0.25	0.21	0.20	0.20	0.21	0.19
CO_2	1.64	0.18	0.18	0.12	0.36	0.28
H_2O^+	3.88	1.35	1.56	1.78	2.45	2.31
H_2O^-	0.31	0.27	0.20	0.23	0.30	0.24
Total	100.1	99.4	99.5	98.7	99.0	99.7

TABLE 4 CONT'D.

Field Code	3-3-86	3-3-87	3-3-88	3-3-89	3-3-90	3-3-91
Sample	37	38	39	40	41	42
SiO_2	47.0	47.4	46.2	46.8	47.4	47.8
Al_2O_3	14.9	15.1	14.0	16.1	15.4	14.5
Fe_2O_3	2.40	2.00	0.80	0.85	2.86	2.80
FeO	9.58	10.9	10.1	8.69	8.86	9.02
MgO	5.82	6.69	7.51	4.26	5.01	4.34
CaO	12.3	9.78	7.87	9.06	10.3	11.8
Na_2O	1.47	3.10	2.09	2.86	1.86	0.48
K_2O	0.10	0.16	0.06	0.65	0.15	0.18
TiO_2	0.88	0.91	0.89	0.97	0.91	1.09
P_2O_5	0.07	0.08	0.07	0.07	0.08	0.09
S	0.01	0.09	0.06	0.03	0.05	0.03
MnO	0.22	0.22	0.18	0.19	0.22	0.24
CO_2	0.96	0.40	5.00	5.12	1.96	3.24
H_2O^+	2.12	2.06	4.76	3.45	2.62	3.40
H_2O^-	0.34	0.28	0.29	0.34	0.52	0.44
Total	98.2	99.2	99.9	99.4	98.2	99.4

Field Code	3-3-92	3-3-93	3-3-94	3-3-95	3-3-96	3-3-97
Sample	43	44	45	46	47	48
SiO_2	48.7	54.6	46.8	52.2	44.4	46.2
Al_2O_3	14.5	16.2	14.2	16.4	15.2	16.2
Fe_2O_3	2.30	1.18	1.08	1.63	2.10	2.50
FeO	10.1	7.41	8.21	7.16	10.4	9.58
MgO	7.29	2.87	5.84	5.05	5.94	6.50
CaO	8.75	5.90	9.32	6.42	10.4	9.56
Na_2O	1.71	2.47	1.51	3.03	1.96	1.92
K_2O	0.22	1.17	1.04	0.58	0.03	0.22
TiO_2	1.11	1.11	0.92	1.00	1.02	1.04
P_2O_5	0.09	0.05	0.08	0.07	0.07	0.09
S	<0.01	0.02	0.01	0.02	0.03	<0.01
MnO	0.22	0.21	0.18	0.20	0.25	0.22
CO_2	0.38	3.14	7.08	2.30	2.76	1.20
H_2O^+	2.93	3.18	3.89	3.34	3.51	3.52
H_2O^-	0.48	0.41	0.34	0.39	0.43	0.36
Total	98.8	99.9	100.5	99.8	98.5	99.1

TABLE 4 CONT'D.

Field Code	3-3-98	3-3-99	3-3-100	3-3-101	3-3-102	3-3-103
Sample	49	50	51	52	53	54
SiO_2	50.4	54.0	51.6	45.9	46.6	47.6
Al_2O_3	14.9	14.5	14.8	16.5	16.1	15.1
Fe_2O_3	1.60	1.89	2.01	2.40	2.69	2.29
FeO	10.1	7.57	7.73	10.1	8.29	8.29
MgO	7.64	5.06	6.26	7.51	7.67	5.93
CaO	6.79	7.77	9.27	10.1	11.6	11.6
Na_2O	3.90	4.85	4.38	2.23	1.63	1.72
K_2O	0.09	0.50	0.31	0.16	0.11	0.09
TiO_2	1.03	0.82	0.80	0.91	0.80	0.81
P_2O_5	0.09	0.07	0.07	0.07	0.07	0.06
S	<0.01	<0.01	0.02	<0.01	0.02	0.02
MnO	0.22	0.24	0.22	0.24	0.21	0.22
CO_2	0.24	0.48	0.40	0.36	0.16	1.86
H_2O^+	2.57	2.17	1.74	2.80	2.34	2.39
H_2O^-	0.31	0.28	0.28	0.25	0.30	0.32
Total	99.9	100.2	99.9	99.5	98.6	98.3

Field Code	3-3-104	3-3-105	3-5-2	3-6-3	3-6-4	3-6-7
Sample	55	56	57	58	59	60
SiO_2	48.0	48.3	45.8	48.4	44.6	72.7
Al_2O_3	14.7	13.7	15.5	14.6	14.6	15.1
Fe_2O_3	2.25	2.20	1.10	5.00	1.90	0.47
FeO	8.69	12.9	9.31	7.56	12.0	0.91
MgO	6.19	6.78	5.82	7.71	11.8	0.66
CaO	11.9	8.10	9.46	10.7	8.27	1.09
Na_2O	1.87	2.35	3.21	2.49	1.54	4.90
K_2O	0.23	0.17	0.08	0.49	0.34	2.15
TiO_2	0.80	1.03	0.97	0.90	0.94	0.22
P_2O_5	0.07	0.09	0.05	0.05	0.04	0.05
S	0.05	0.05	0.02	0.07	<0.01	0.05
MnO	0.21	0.24	0.32	0.22	0.25	0.02
CO_2	1.70	0.22	4.12	0.48	0.44	0.48
H_2O^+	2.18	2.90	3.30	0.98	3.58	0.57
H_2O^-	0.28	0.34	0.44	0.46	0.49	0.41
Total	99.1	99.4	99.5	100.1	100.8	99.8

TABLE 4 CONT'D.

Field Code	3-6-8	3-6-9	3-7-8	3-7-10	3-7-15	3-7-21
Sample	61	62	63	64	65	66
SiO_2	57.6	55.8	53.0	44.5	51.2	57.0
Al_2O_3	16.6	15.5	14.3	17.8	17.0	16.2
Fe_2O_3	2.89	3.90	1.37	2.13	2.17	1.33
FeO	4.40	7.56	8.31	10.7	8.23	7.65
MgO	3.34	4.52	6.33	7.90	5.57	3.37
CaO	7.55	2.13	11.6	10.5	8.93	5.91
Na_2O	1.20	5.50	1.51	1.38	2.13	2.64
K_2O	3.07	0.14	0.57	0.43	0.71	1.44
TiO_2	0.92	1.60	0.80	1.05	1.07	0.94
P_2O_5	0 08	0.30	0.09	0.09	0.15	0.21
S	0.01	<0.01	0.13	0.10	0.27	0.01
MnO	0.15	0.15	0.19	0.22	0.16	0.21
CO_2	0.44	0.48	0.42	0.34	0.24	0.26
H_2O^+	1.34	2.40	0.67	2.57	0.81	1.29
H_2O^-	0.43	0.40	0.38	0.45	0.41	0.42
Total	100.0	100.4	99.7	100.2	99.0	98.9
Field Code	**3-15-2**	**3-18-1**	**3-18-4**	**3-18-5**	**3-18-6**	**3-18-7**
Sample	**67**	**68**	**69**	**70**	**71**	**72**
SiO_2	46.5	50.1	41.9	47.5	47.8	49.7
Al_{2O3}	15.1	14.7	15.0	13.7	13.2	13.3
Fe_2O_3	0.50	4.00	2.80	3.90	3.00	3.70
FeO	6.53	9.29	9.37	9.98	9.29	10.4
MgO	8.33	4.90	13.7	5.78	5.92	6.21
CaO	7.78	9.34	8.08	11.5	10.5	7.19
Na_2O	0.05	2.82	1.31	1.72	2.04	2.74
K_2O	1.53	0.19	0.03	0.05	0.25	0.28
TiO_2	0.38	1.20	0.59	1.10	0.96	1.40
P_2O_5	0.02	0.13	0.04	0.09	0.10	0.13
S	0.15	0.37	<0.01	0.05	0.01	0.14
MnO	0.12	0.22	0.21	0.22	0.23	0.24
CO_2	6.67	0.40	0.45	0.76	3.94	1.48
H_2O^+	4.68	2.20	4.70	2.24	3.01	3.25
H_2O^-	0.43	0.49	0.62	0.51	0.39	0.62
Total	98.8	100.3	98.8	99.1	100.6	100.8

TABLE 4 CONT'D.

Field Code	3-18-8	3-18-9	3-18-10	3-18-11	3-18-12	3-18-13
Sample	73	74	75	76	77	78
SiO_2	50.6	48.8	47.6	48.3	52.6	50.3
Al_2O_3	14.1	14.9	14.8	15.4	13.1	14.5
Fe_2O_3	4.60	3.35	4.04	2.90	4.78	3.30
FeO	9.29	8.60	8.52	10.1	6.14	10.1
MgO	5.20	7.17	6.65	6.72	5.66	6.37
CaO	8.51	10.5	11.8	8.88	13.0	6.27
Na_2O	2.64	1.87	1.27	2.30	0.85	3.21
K_2O	0.15	0.20	0.23	0.09	0.01	0.11
TiO_2	1.20	0.83	0.89	1.00	1.00	1.57
P_2O_5	0.15	0.09	0.10	0.10	0.11	0.18
S	0.03	0.01	0.02	0.03	0.03	<0.01
MnO	0.21	0.23	0.24	0.18	0.19	0.19
CO_2	0.42	0.29	0.38	0.64	0.25	0.29
H_2O^+	2.59	2.76	2.38	3.40	1.20	3.18
H_2O^-	0.56	0.47	0.40	0.49	0.45	0.60
Total	100.2	100.1	99.3	100.5	99.4	100.2
Field Code	**3-19-1**	**3-19-2**	**3-19-3**	**3-19-4**	**3-19-5**	**3-19-6**
Sample	**79**	**80**	**81**	**82**	**83**	**84**
SiO_2	49.4	47.0	49.4	50.0	50.7	47.2
Al_2O_3	14.1	15.1	14.9	12.5	15.6	15.0
Fe_2O_3	4.70	2.71	3.00	7.00	2.69	3.49
FeO	10.4	8.99	10.5	10.8	8.29	8.29
MgO	6.14	7.69	6.32	4.47	4.95	6.90
CaO	8.25	11.3	8.39	7.13	10.4	12.8
Na_2O	2.33	1.31	1.81	1.89	2.28	1.44
K_2O	0.21	0.19	0.14	0.04	0.21	0.32
TiO_2	1.28	0.78	1.06	1.82	0.92	0.98
P_2O_5	0.13	0.08	0.10	0.16	0.10	0.09
S	0.12	0.14	0.02	0.16	0.10	0.05
MnO	0.23	0.21	0.25	0.23	0.22	0.20
CO_2	0.40	1.57	0.83	0.12	1.40	0.44
H_2O^+	2.57	2.20	3.28	2.97	2.20	2.12
H_2O^-	0.56	0.39	0.45	0.57	0.42	0.38
Total	100.8	99.7	100.4	99.9	100.5	99.7

TABLE 4 CONT'D.

Field Code Sample	3-19-7 85	3-19-8 86	3-19-9 87	3-20-1 88	3-20-2 89	3-20-3 90
SiO_2	48.7	46.5	47.2	48.1	45.8	46.9
Al_2O_3	15.2	13.0	15.1	14.2	15.6	15.2
Fe_2O_3	3.50	2.56	3.30	3.90	4.24	3.37
FeO	10.3	9.22	8.83	8.91	8.52	8.22
MgO	5.37	4.32	7.51	7.29	7.86	7.14
CaO	6.40	10.6	11.2	10.8	11.2	11.8
Na_2O	3.76	2.62	1.39	1.50	1.42	1.30
K_2O	0.36	0.21	0.16	0.32	0.23	0.13
TiO_2	1.41	1.23	0.83	0.91	0.86	0.77
P_2O_5	0.16	0.12	0.08	0.08	0.09	0.08
S	0.10	0.10	0.02	0.11	0.05	0.09
MnO	0.23	0.21	0.21	0.20	0.23	0.20
CO_2	0.22	5.89	0.22	0.17	0.17	0.40
H_2O^+	3.18	3.31	2.66	2.39	2.86	2.53
H_2O^-	0.46	0.42	0.34	0.46	0.58	0.47
Total	99.3	100.3	99.0	99.3	99.7	98.6

Field Code Sample	3-20-4 91*	3-20-6 92	3-20-7 93	3-20-8 94*	3-21-2 95	3-21-3 96
SiO_2	51.6	47.0	65.6	49.1	48.0	49.6
Al_2O_3	13.7	15.0	15.4	17.1	13.7	13.3
Fe_2O_3	4.67	3.70	1.53	2.36	1.30	3.89
FeO	7.68	9.29	4.07	5.99	9.45	8.83
MgO	5.92	6.93	1.69	6.52	5.68	6.32
CaO	7.75	12.1	1.66	10.8	10.9	9.12
Na_2O	2.65	1.21	4.37	2.24	2.21	2.16
K_2O	0.31	0.23	1.27	0.04	0.11	1.78
TiO_2	1.27	0.91	0.30	0.71	1.08	1.10
P_2O_5	0.16	0.09	0.08	0.08	0.12	0.10
S	0.01	0.05	0.26	0.01	0.10	0.13
MnO	0.22	0.22	0.15	0.19	0.19	0.18
CO_2	1.13	0.16	1.27	2.00	3.81	0.74
H_2O^+	2.39	2.38	2.06	2.51	2.41	1.96
H_2O^-	1.00	0.46	0.45	0.53	0.45	0.90
Total	100.5	99.7	100.2	100.2	99.5	100.1

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code	3-21-6	3-21-7	3-21-8	3-22-1	3-22-2	3-24-1
Sample	97	98	99	100	101	102
SiO_2	48.3	49.7	47.8	50.0	64.3	54.2
Al_2O_3	14.4	15.2	15.2	15.3	14.1	16.3
Fe_2O_3	4.05	3.13	2.59	2.32	1.61	2.16
FeO	8.60	7.99	8.83	6.91	6.30	5.76
MgO	5.94	5.99	7.79	7.93	1.67	6.76
CaO	11.2	7.64	10.9	10.4	3.60	4.75
Na_2O	1.59	2.28	2.39	2.04	0.01	5.56
K_2O	0.10	0.31	0.23	0.41	2.76	0.44
TiO_2	0.84	0.79	0.77	0.72	0.29	0.73
P_2O_5	0.09	0.08	0.08	0.07	0.09	0.14
S	0.06	0.01	0.03	<0.01	<0.01	0.02
MnO	0.22	0.24	0.22	0.18	0.11	0.11
CO_2	1.14	3.29	0.23	0.69	3.13	0.11
H_2O^+	2.42	3.81	2.01	2.10	2.60	2.33
H_2O^-	0.36	0.42	0.42	0.36	0.34	0.34
Total	99.3	100.9	99.5	99.4	100.9	99.7

Field Code	3-24-2	3-24-3	4-13-5	4-13-100	4-15-1A	4-15-2
Sample	103*	104	105	106	107	108
SiO_2	48.3	48.6	49.1	60.3	46.8	67.9
Al_2O_3	15.3	14.8	14.8	14.3	14.8	16.6
Fe_2O_3	4.66	3.46	1.70	1.81	2.50	0.81
FeO	7.60	10.3	10.1	5.03	11.2	2.30
MgO	6.71	6.26	8.47	3.90	7.67	0.78
CaO	11.2	9.93	7.11	3.70	10.2	1.43
Na_2O	1.65	2.47	2.75	3.81	2.07	5.85
K_2O	0.20	0.38	0.03	1.24	0.01	1.14
TiO_2	0.90	1.18	0.90	0.72	0.97	0.45
P_2O_5	0.10	0.07	0.04	0.17	0.06	0.10
S	0.05	0.05	0.11	0.02	0.05	0.01
MnO	0.21	0.23	0.19	0.11	0.25	0.04
CO_2	0.13	0.19	1.04	0.62	0.32	1.37
H_2O^+	2.19	0.23	3.22	2.49	2.51	1.48
H_2O^-	0.35	0.55	0.33	0.33	0.26	0.38
Total	99.5	98.7	99.9	96.5	99.7	100.6

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code Sample	4-15-4 109	4-15-5 110	4-15-7 111	4-16-2A 112	4-16-4 113	4-18-1 114
SiO_2	67.7	68.1	51.0	68.0	48.2	53.5
Al_2O_3	16.2	16.2	15.7	16.0	14.7	15.5
Fe_2O_3	0.92	0.82	1.26	0.26	2.78	2.74
FeO	2.53	2.46	6.45	2.92	10.1	5.84
MgO	1.08	1.06	6.89	1.08	6.76	5.30
CaO	1.45	0.72	7.00	0.84	7.71	7.38
Na_2O	4.27	6.18	5.43	7.07	3.05	2.64
K_2O	1.50	0.75	0.37	0.33	0.19	0.87
TiO_2	0.43	0.44	0.80	0.45	1.01	0.87
P_2O_5	0.08	0.03	0.07	0.08	0.05	0.22
S	0.01	0.01	0.10	0.01	0.03	<0.01
MnO	0.04	0.03	0.20	0.04	0.24	0.14
CO_2	1.15	0.50	1.90	0.63	0.56	0.99
H_2O^+	1.85	1.73	2.22	1.14	2.98	2.42
H_2O^-	0.36	0.32	0.35	0.35	0.48	0.32
Total	99.6	99.3	99.7	99.2	98.8	98.7

Field Code Sample	4-18-4 115	4-18-5 116	4-18-7 117*	4-18-8 118	4-18-9 119*	4-18-10 120
SiO_2	48.0	59.9	41.8	50.5	47.6	56.0
Al_2O_3	15.7	14.7	14.9	16.5	12.6	15.1
Fe_2O_3	2.98	1.84	2.70	2.26	18.2	0.70
FeO	10.1	3.92	9.14	10.3	0.0	3.76
MgO	6.89	4.40	14.7	4.12	5.82	2.26
CaO	9.48	6.29	9.62	6.30	8.84	7.71
Na_2O	2.49	2.98	0.46	1.88	1.75	6.94
K_2O	0.03	1.36	0.06	0.43	0.06	0.01
TiO_2	0.97	0.68	0.50	0.88	2.03	0.69
P_2O_5	0.05	0.21	0.05	0.29	0.16	0.13
S	0.03	<0.01	<0.01	<0.01	4.84	<0.01
MnO	0.25	0.12	0.19	0.32	0.20	0.07
CO_2	0.59	1.44	0.38	1.20	0.18	5.67
H_2O^+	2.66	1.89	4.66	3.64	3.40	1.60
H_2O^-	0.38	0.26	0.58	0.59	0.53	0.27
Total	100.6	100.0	99.7	99.2	106.2	100.9

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code Sample	4-18-12 121	4-18-13 122	4-18-14 123	4-18-15 124	4-18-16 125	4-19-1 126
SiO_2	62.1	32.7	54.6	54.5	60.0	57.7
Al_2O_3	14.5	18.6	15.1	17.5	16.9	15.9
Fe_2O	1.83	5.30	4.55	2.31	2.11	1.91
FeO	4.30	16.6	5.99	5.15	3.99	4.84
MgO	4.05	6.87	2.88	3.28	3.57	5.58
CaO	5.24	8.56	10.8	6.54	6.06	6.40
Na_2O	3.53	0.01	0.01	5.77	3.44	2.43
K_2O	1.66	0.20	0.01	0.45	0.84	1.11
TiO_2	0.68	3.02	1.60	1.52	0.65	0.70
P_2O_5	0.13	0.48	0.27	0.21	0.16	0.15
S	0.04	<0.01	<0.01	0.15	<0.01	0.01
MnO	0.11	0.38	0.23	0.13	0.10	0.12
CO_2	0.17	0.13	0.92	0.14	0.20	0.30
H_2O^+	1.50	6.30	2.70	1.45	1.80	1.93
H_2O^-	0.26	0.53	0.32	0.28	0.29	0.61
Total	100.1	99.7	100.0	99.4	100.1	99.7

Field Code Sample	4-19-2 127	4-19-3 128	4-19-4 129	4-19-6 130	4-20-2A 131	4-20-3A 132
SiO_2	60.6	65.5	52.7	59.8	59.3	59.9
Al_2O_3	15.0	17.6	18.7	15.8	15.1	14.9
Fe_2O_3	1.76	1.78	4.64	2.22	1.21	1.01
FeO	4.61	2.76	3.84	3.69	5.76	6.07
MgO	3.88	1.74	3.36	3.58	4.45	5.28
CaO	4.59	0.66	10.8	5.97	3.82	5.48
Na_2O	4.99	6.43	0.93	2.90	0.69	3.26
K_2O	0.26	0.61	0.92	1.45	2.61	1.22
TiO_2	0.78	0.54	0.91	0.61	0.69	0.79
P_2O_5	0.21	0.13	0.23	0.15	0.13	0.19
S	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
MnO	0.11	0.02	0.11	0.09	0.08	0.13
CO_2	0.41	0.42	0.21	1.33	2.92	0.26
H_2O^+	2.00	1.60	2.10	1.60	2.95	1.77
H_2O^-	0.62	0.59	0.61	0.60	0.70	0.62
Total	99.8	100.4	100.1	99.8	100.4	100.9

TABLE 4 CONT'D.

Field Code Sample	4-20-4 133	4-20-5 134	4-20-12 135	4-20-14 136	4-20-15 137	4-20-16 138
SiO_2	64.0	63.0	56.4	59.5	63.9	60.1
Al_2O_3	14.0	15.2	14.7	16.2	15.3	16.1
Fe_2O_3	1.72	1.29	1.69	2.11	1.20	2.73
FeO	4.22	4.30	5.84	4.61	4.07	3.99
MgO	3.49	3.72	4.11	3.71	3.00	3.14
CaO	5.48	5.09	5.32	5.54	4.54	7.45
Na_2O	2.47	3.83	4.42	4.40	3.85	1.15
K_2O	0.73	0.38	0.38	0.63	0.68	0.59
TiO_2	0.70	0.81	1.29	0.92	0.85	0.83
P_2O_3	0.14	0.16	0.30	0.15	0.16	0.15
S	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
MnO	0.11	0.11	0.13	0.10	0.08	0.11
CO_2	0.27	0.45	2.39	0.38	0.36	0.39
H_2O^+	1.59	1.43	2.82	1.86	1.44	1.81
H_2O^-	0.56	0.64	0.53	0.57	0.55	0.67
Total	99.5	100.4	100.3	100.7	100.0	99.2

Field Code Sample	4-20-18 139	4-21-1 140	4-21-2 141	4-21-3 142	4-21-4 143	4-21-6 144
SiO_2	57.5	61.4	59.2	59.2	57.2	51.6
Al_2O_3	16.2	15.8	15.9	15.4	15.2	14.9
Fe_2O_3	3.40	2.09	2.22	1.54	1.76	2.04
FeO	4.92	4.07	5.07	5.53	6.07	8.52
MgO	1.78	2.77	5.31	3.28	1.65	4.59
CaO	8.30	4.90	1.71	4.58	5.89	6.27
Na_2O	3.00	2.22	4.72	4.61	4.83	3.98
K_2O	0.07	1.26	0.22	0.90	0.36	0.01
TiO_2	1.81	0.70	0.96	1.45	1.63	1.69
P_2O_5	0.22	0.16	0.23	0.21	0.25	0.30
S	0.01	<0.01	<0.01	0.05	0.06	0.35
MnO	0.21	0.09	0.11	0.12	0.21	0.18
CO_2	1.21	0.45	0.13	0.35	2.60	2.90
H_2O^+	1.88	2.30	2.80	1.70	1.40	3.20
H_2O^-	0.62	0.60	0.64	0.57	0.58	0.40
Total	101.2	98.8	99.2	99.5	99.7	100.9

TABLE 4 CONT'D.

Field Code	4-21-7	4-21-8	4-21-9	4-21-10	4-21-11	4-22-1
Sample	145	146	147	148	149	150
SiO_2	55.7	46.8	46.8	45.2	49.8	56.0
Al_2O_3	14.5	14.8	15.6	16.5	15.3	13.9
Fe_2O_3	1.58	3.10	3.51	2.60	2.50	1.66
FeO	7.45	9.29	8.91	10.4	8.29	3.61
MgO	5.22	7.37	6.44	7.89	6.62	1.49
CaO	4.20	10.1	11.6	11.7	9.43	8.78
Na_2O	4.47	1.45	1.39	1.18	2.66	1.20
K_2O	0.74	0.35	0.25	0.23	0.19	2.80
TiO_2	1.68	0.83	0.92	0.89	0.81	0.49
P_2O_5	0.35	0.08	0.10	0.07	0.06	0.11
S	0.09	0.01	0.12	0.28	0.04	0.02
MnO	0.17	0.23	0.20	0.21	0.20	0.17
CO_2	0.58	0.67	0.49	0.12	2.10	6.85
H_2O^+	2.47	2.72	1.88	1.10	2.09	1.82
H_2O^-	0.34	0.50	0.48	0.62	0.54	0.69
Total	99.5	98.3	98.7	99.0	100.6	99.6
Field Code	**4-22-2**	**4-22-3**	**4-22-4**	**4-22-5**	**4-22-6**	**4-22-7**
Sample	**151**	**152**	**153**	**154**	**155**	**156**
SiO_2	65.9	64.9	49.1	47.0	47.5	49.1
Al_2O_3	17.2	16.1	15.0	14.5	15.8	13.3
Fe_2O_3	1.41	1.23	3.10	3.10	2.51	3.70
FeO	2.77	2.53	9.45	9.60	8.91	10.6
MgO	1.33	1.96	6.80	7.93	7.12	5.56
CaO	1.30	2.61	7.86	9.40	11.3	8.91
Na_2O	4.80	5.03	2.71	1.98	2.21	3.26
K_2O	1.74	0.76	0.29	0.55	0.05	0.30
TiO_2	0.53	0.49	0.89	0.90	0.78	1.28
P_2O_5	0.11	0.11	0.08	0.09	0.06	0.12
S	<0.01	<0.01	0.04	0.03	0.08	0.03
MnO	0.05	0.06	0.23	0.21	0.19	0.22
CO_2	1.26	2.13	1.31	0.41	0.80	0.87
H_2O^+	1.55	1.26	2.92	2.75	1.86	2.09
H_2O^-	0.62	0.62	0.55	0.50	0.41	0.50
Total	100.6	99.8	100.3	98.9	99.6	99.8

TABLE 4 CONT'D.

Field Code Sample	4-22-8 157	4-22-9 158	4-22-11 159	4-22-12 160	4-24-1 161	4-24-3 162
SiO_2	48.9	47.7	48.8	47.3	47.3	64.2
Al_2O_3	13.5	14.6	13.1	14.3	13.1	15.5
Fe_2O_3	4.30	4.60	3.80	3.10	3.20	1.25
FeO	10.9	9.37	10.3	9.75	10.2	2.76
MgO	6.11	6.99	5.67	7.65	5.28	1.71
CaO	8.00	11.0	9.15	6.68	7.17	3.17
Na_2O	3.40	1.15	2.17	1.54	3.09	5.39
K_2O	0.07	0.01	0.28	0.10	0.01	1.00
TiO_2	1.37	0.91	1.27	0.84	1.26	0.44
P_2O_5	0.13	0.09	0.09	0.08	0.11	0.12
S	0.05	0.04	0.02	0.07	0.06	<0.01
MnO	0.24	0.23	0.23	0.19	0.20	0.04
CO_2	0.11	0.40	1.54	3.38	5.20	2.01
H_2O^+	2.44	2.57	2.80	4.56	3.93	1.52
H_2O^-	0.52	0.49	0.44	0.49	0.39	0.34
Total	100.0	100.1	99.7	100.0	100.5	99.5

Field Code Sample	4-24-4 163	4-25-1 164	4-26-6 165	4-26-10 166	4-26-11 167	4-26-12 168
SiO_2	77.8	59.0	49.2	70.1	66.9	68.5
Al_2O_3	15.0	18.3	12.8	16.6	15.5	15.9
Fe_2O_3	0.01	1.84	5.10	1.43	0.36	1.35
FeO	0.31	4.61	12.1	1.23	2.23	1.54
MgO	0.18	2.56	3.93	0.79	1.43	0.68
CaO	0.19	2.88	8.49	2.35	0.88	3.23
Na_2O	1.57	2.92	2.36	5.91	8.16	4.54
K_2O	1.46	2.58	0.33	0.73	0.26	0.83
TiO_2	0.29	0.82	1.83	0.26	0.32	0.29
P_2O_5	0.06	0.17	0.21	0.08	0.07	0.08
S	<0.01	<0.01	0.15	0.12	<0.01	0.07
MnO	0.01	0.09	0.26	0.03	0.04	0.04
CO_2	0.18	1.55	0.24	0.13	0.59	0.25
H_2O^+	1.43	2.59	2.28	0.53	1.16	0.87
H_2O^-	0.40	0.36	0.34	0.33	0.28	0.26
Total	98.9	100.3	99.6	100.6	98.2	98.4

TABLE 4 CONT'D.

Field Code	4-26-13	4-27-1	5-6-101	5-6-108	5-8-1/9	5-12-2
Sample	169*	170*	171	172	173	174
SiO_2	47.8	47.7	48.8	59.0	50.9	48.6
Al_2O_3	13.8	13.5	15.8	15.0	17.5	15.7
Fe_2O_3	6.08	4.10	1.34	1.79	1.01	2.64
FeO	7.22	10.8	9.34	4.78	7.15	8.35
MgO	6.30	5.60	8.05	4.16	4.81	4.36
CaO	11.3	9.34	8.15	8.44	8.88	9.53
Na_2O	3.06	2.26	2.86	3.39	2.42	3.68
K_2O	0.33	1.19	0.16	0.04	0.57	0.64
TiO_2	1.18	1.94	0.83	0.80	1.00	0.94
P_2O_5	0.10	0.31	0.07	0.10	0.09	0.09
S	0.08	0.18	<0.01	0.09	0.07	0.02
MnO	0.20	0.23	0.22	0.14	0.19	0.24
CO_2	0.20	0.05	0.50	0.42	1.88	1.40
H_2O	1.10	1.18	2.71	1.05	2.46	2.27
H_2O	0.42	0.67	0.36	0.30	0.49	0.44
Total	99.2	99.0	99.2	99.5	99.4	98.9

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

Field Code	5-15-1	5-15-3	5-15-4	5-15-5	5-15-6	5-15-7
Sample	175	176	177	178	179	180
SiO_2	50.7	66.4	48.6	51.9	47.7	49.0
Al_2O_3	15.9	14.7	17.2	14.7	14.7	15.1
Fe_2O_3	2.63	0.01	2.06	3.62	2.91	2.23
FeO	7.53	6.68	10.3	7.45	8.99	7.53
MgO	6.65	2.45	6.46	6.35	4.16	6.42
CaO	9.59	1.92	3.97	7.36	10.6	12.8
Na_2O	2.42	1.68	2.84	0.14	0.62	0.77
K_2O	0.03	1.18	0.01	0.01	0.01	0.29
TiO_2	0.73	0.72	1.19	1.02	1.07	0.73
P_2O_5	0.04	0.06	0.04	0.05	1.00	0.04
S	0.17	0.14	<0.01	0.08	0.16	0.03
MnO	0.19	0.08	0.24	0.27	0.25	0.19
CO_2	0.37	1.40	1.04	1.61	4.55	1.46
H_2O^+	2.07	2.32	4.25	3.51	3.26	1.66
H_2O^-	0.57	0.60	0.74	0.72	0.73	0.39
Total	99.6	100.3	98.9	98.8	100.7	98.6

TABLE 4 CONT'D.

Field Code Sample	5-15-8 181	5-15-9 182	5-15-10 183	5-15-13 184	5-17-1A 185	5-17-4 186
SiO_2	49.9	52.4	47.8	50.2	48.3	50.1
Al_2O_3	14.1	15.9	16.0	14.6	15.8	15.9
Fe_2O_3	5.33	2.50	2.03	5.29	0.13	1.67
FeO	7.53	7.83	10.5	6.76	8.68	8.76
MgO	7.47	4.66	6.35	6.27	3.81	8.41
CaO	7.50	8.46	6.72	8.61	11.0	7.37
Na_2O	0.29	1.93	0.98	0.39	2.68	1.99
K_2O	0.03	0.01	0.01	0.01	0.01	1.24
TiO_2	1.07	1.07	1.12	1.03	0.96	0.78
P_2O_5	0.05	0.07	0.06	0.06	0.07	0.05
S	0.23	0.14	0.02	0.02	0.03	0.04
MnO	0.34	0.24	0.29	0.28	0.22	0.19
CO_2	1.05	1.66	1.68	1.90	5.20	0.30
H_2O^+	3.52	2.99	4.25	3.30	2.92	2.11
H_2O^-	0.59	0.58	0.62	0.70	0.52	0.71
Total	99.0	100.4	98.4	99.4	100.3	99.6

Field Code Sample	5-17-5 187	5-17-6 188	5-17-7 189*	5-18-1 190	5-18-2 191	5-18-4 192
SiO_2	66.2	48.9	49.0	54.7	65.4	52.0
Al_2O_3	16.8	15.8	16.1	13.6	13.9	15.9
Fe_2O_3	0.84	2.27	2.31	2.46	0.92	0.97
FeO	4.07	8.22	7.37	9.22	5.15	8.22
MgO	1.72	6.00	6.93	3.71	1.12	7.26
CaO	1.32	10.0	10.7	5.43	3.55	6.41
Na_2O	5.84	1.80	1.82	2.38	3.69	4.65
K_2O	0.14	0.09	0.18	0.01	0.65	0.01
TiO_2	0.58	1.19	0.98	1.89	0.55	0.96
P_2O_5	0.12	0.07	0.04	0.14	0.16	0.05
S	0.12	0.15	0.02	0.11	<0.01	0.11
MnO	0.07	0.20	0.23	0.28	0.18	0.19
CO_2	0.58	1.40	1.12	2.34	2.92	0.29
H_2O^+	1.33	2.42	1.96	3.56	1.80	1.92
H_2O^-	0.51	0.56	0.51	0.73	0.62	0.61
Total	100.2	99.1	99.3	100.6	100.6	99.5

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code Sample	5-18-3 193	5-19-1 194	5-20-1 195	5-20-2 196	5-20-3 197	5-20-4 198
SiO_2	50.0	66.1	47.7	51.4	57.0	50.8
Al_2O_3	15.6	16.3	15.7	14.3	16.1	13.3
Fe_2O_3	3.25	0.75	2.30	2.83	1.37	2.60
FeO	4.61	5.99	8.91	10.5	5.07	10.5
MgO	3.42	1.67	8.07	6.22	5.31	5.10
CaO	13.9	1.89	8.86	4.08	5.32	7.94
Na_2O	1.04	2.27	1.00	2.16	3.98	5.16
K_2O	0.01	0.59	0.02	0.01	1.18	0.01
TiO_2	0.80	0.60	0.82	1.81	0.87	1.47
P_2O_5	0.03	0.12	0.05	0.16	0.23	0.14
S	0.40	<0.01	0.02	0.18	0.01	0.04
MnO	0.18	0.10	0.22	0.24	0.11	0.28
CO_2	4.65	1.35	1.04	1.55	0.31	0.94
H_2O^+	1.66	2.48	3.10	4.61	1.98	1.80
H_2O^-	0.51	0.53	0.69	0.72	0.56	0.62
Total	100.1	100.7	98.5	100.8	99.4	100.7

Field Code Sample	5-20-5 199	5-20-100 200	5-23-1 201	5-23-3 202	5-23-4 203	5-23-5 204
SiO_2	47.9	70.0	57.9	56.0	54.1	52.0
Al_2O_3	15.7	15.8	16.2	14.4	16.0	14.7
Fe_2O_3	3.81	0.31	2.60	2.78	1.76	4.25
FeO	6.30	1.15	4.84	6.68	6.14	8.06
MgO	5.57	0.34	3.63	5.42	5.96	4.16
CaO	11.6	1.98	4.55	5.39	5.33	5.38
Na_2O	0.13	4.78	4.18	3.92	4.38	3.29
K_2O	0.01	1.70	1.24	0.76	0.78	0.68
TiO_2	0.91	0.44	0.73	0.96	1.12	2.15
P_2O_5	0.10	0.12	0.15	0.22	0.18	0.18
S	0.05	<0.01	<0.01	<0.01	<0.01	0.06
MnO	0.23	0.27	0.10	0.15	0.14	0.15
CO_2	3.30	1.46	0.28	0.20	0.19	0.48
H_2O^+	2.90	1.00	1.93	2.09	2.52	3.00
H_2O^-	0.44	0.30	0.62	0.58	0.55	0.62
Total	98.9	99.7	99.0	99.6	99.2	99.2

TABLE 4 CONT'D.

Field Code Sample	5-24-1 205	5-24-4 206	5-24-5 207	5-24-6 208	5-24-7 209	5-24-9 210
SiO_2	62.7	58.9	60.7	46.8	60.8	55.6
Al_2O_3	15.3	14.7	15.7	15.5	16.5	15.7
Fe_2O_3	1.27	2.67	1.77	5.15	1.26	1.67
FeO	3.76	2.23	4.30	8.60	3.15	5.38
MgO	2.35	1.96	3.43	6.44	1.99	6.39
CaO	3.27	11.3	2.52	8.84	3.14	3.68
Na_2O	4.05	0.41	5.62	2.44	6.53	4.09
K_2O	2.82	1.77	1.10	0.23	0.95	2.68
TiO_2	0.55	0.45	0.66	1.29	0.58	0.90
P_2O_5	0.09	0.07	0.11	0.07	0.09	0.11
S	0.08	<0.01	0.02	0.04	<0.01	<0.01
MnO	0.13	0.09	0.10	0.20	0.08	0.08
CO_2	1.30	3.27	0.59	0.50	2.47	0.37
H_2O^+	1.58	0.90	1.73	2.69	1.16	2.24
H_2O^-	0.50	0.53	0.58	0.71	0.67	0.70
Total	99.7	99.3	98.9	99.5	99.4	99.6

Field Code Sample	5-24-10 211	5-25-1 212	5-25-2 213	5-25-3 214	5-25-4 215	5-25-11 216*
SiO_2	60.7	58.5	53.8	62.1	47.3	50.3
Al_2O_3	15.4	16.1	16.8	13.8	14.5	15.5
Fe_2O_3	3.71	2.68	3.58	1.63	3.30	2.77
FeO	4.61	4.45	5.53	4.92	8.37	6.14
MgO	2.46	3.97	3.94	4.26	6.82	6.50
CaO	2.39	4.12	8.83	3.07	11.1	11.7
Na_2O	5.94	5.60	3.12	5.82	1.11	3.21
K_2O	0.52	0.48	0.21	0.41	0.01	0.14
TiO_2	1.51	1.16	1.05	0.99	0.82	0.82
P_2O_5	0.35	0.26	0.23	0.22	0.03	0.01
S	0.05	0.14	<0.01	0.08	0.04	0.02
MnO	0.05	0.11	0.14	0.09	0.20	0.17
CO_2	0.41	0.11	0.31	0.49	2.65	1.19
H_2O^+	1.46	1.79	1.76	1.31	3.12	0.99
H_2O^-	0.64	0.57	0.65	0.90	0.78	0.58
Total	100.2	100.0	100.0	100.1	100.1	100.0

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code Sample	5-25-12 217	5-25-13 218	5-25-15 219	5-26-2 220	5-26-5 221	5-26-6 222
SiO_2	49.5	47.0	53.9	47.8	59.3	73.0
Al_2O_3	12.9	16.5	13.4	13.9	13.9	14.8
Fe_2O_3	3.30	3.57	2.21	3.42	1.80	0.54
FeO	10.6	7.68	7.37	10.6	5.06	1.23
MgO	4.94	7.00	8.97	7.25	3.85	0.30
CaO	6.48	10.9	5.21	7.89	4.98	0.77
Na_2O	2.44	2.34	2.26	2.71	3.76	4.60
K_2O	0.10	0.15	0.32	0.42	0.97	1.32
TiO_2	1.34	0.95	0.77	1.17	0.98	0.17
P_2O_5	0.09	0.09	0.15	0.07	0.24	0.01
S	0.10	<0.01	<0.01	0.07	<0.01	<0.01
MnO	0.21	0.19	0.17	0.24	0.12	0.03
CO_2	4.10	1.06	0.26	0.79	1.84	0.91
H_2O^+	4.01	2.39	3.11	2.45	2.00	0.66
H_2O^-	0.86	0.45	0.79	0.79	0.66	0.59
Total	101.0	100.3	98.9	99.6	99.5	98.9

Field Code Sample	5-27-1 223	5-27-6 224*	5-27-10 225	6-16-1 226	6-16-2 227	6-16-4 228
SiO_2	55.4	47.8	47.1	52.6	47.9	49.9
Al_2O_3	16.0	19.0	15.3	16.7	15.1	14.6
Fe_2O_3	1.74	3.06	3.97	2.06	2.46	3.30
FeO	6.14	6.00	8.22	7.60	8.76	8.37
MgO	6.74	6.18	7.72	5.01	6.66	6.06
CaO	4.90	9.69	11.9	8.24	11.3	10.9
Na_2O	3.95	3.02	1.26	2.62	1.44	0.68
K_2O	0.36	0.23	0.29	0.08	0.18	0.21
TiO_2	0.81	0.58	0.64	0.94	0.89	0.96
P_2O_5	0.13	0.01	0.03	0.04	0.05	0.06
S	<0.01	<0.01	0.06	0.08	0.04	0.08
MnO	0.09	0.15	0.20	0.20	0.22	0.21
CO_2	0.26	0.33	0.34	1.07	1.01	0.80
H_2O^+	2.66	1.92	1.13	2.05	1.91	1.66
H_2O^-	0.64	0.64	0.67	0.62	0.74	0.67
Total	99.8	98.6	98.8	99.9	98.7	98.5

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

TABLE 4 CONT'D.

Field Code	6-16-5	6-17-1	6-17-2	6-17-3	6-17-4	6-17-5
Sample	229	230	231	232	233	234
SiO_2	46.6	45.8	49.6	47.2	49.1	47.8
Al_2O_3	16.1	16.0	14.8	15.3	15.7	15.8
Fe_2O_3	3.09	0.77	2.58	3.06	2.99	2.48
FeO	8.83	10.2	7.76	8.14	7.30	9.29
MgO	6.18	10.6	7.94	8.31	7.25	7.65
CaO	12.2	7.50	10.8	11.7	10.7	9.04
Na_2O	0.50	1.95	1.14	1.39	0.93	2.60
K_2O	0.09	0.39	0.12	0.17	0.34	0.05
TiO_2	0.90	0.79	0.78	0.88	0.90	0.64
P_2O_5	0.04	0.03	0.05	0.04	0.05	0.03
S	0.17	0.02	0.04	0.03	0.01	0.13
MnO	0.20	0.22	0.18	0.19	0.20	0.23
CO_2	0.86	0.46	0.48	0.62	0.44	0.89
H_2O^+	1.91	3.82	2.25	2.03	1.87	2.79
H_2O^-	0.70	0.73	0.50	0.53	0.49	0.54
Total	98.4	99.3	99.0	99.6	98.3	100.0

Field Code	6-17-6	6-17-7	6-19-1	6-19-3	6-19-6	6-19-8
Sample	235	236	237	238	239	240
SiO_2	51.0	47.8	48.3	49.2	53.1	55.5
Al_2O_3	17.1	17.3	15.0	14.6	16.6	13.9
Fe_2O_3	2.12	2.37	2.08	2.09	2.96	1.73
FeO	6.84	7.14	10.1	9.37	5.45	6.99
MgO	4.12	7.32	4.30	4.36	3.47	4.97
CaO	10.8	11.0	9.47	10.0	11.3	8.37
Na_2O	2.23	0.62	2.41	1.34	1.59	0.01
K_2O	0.05	0.09	0.05	0.07	0.04	0.32
TiO_2	0.98	1.01	1.12	1.06	1.00	0.78
P_2O_5	0.06	0.04	0.08	0.10	0.06	0.05
S	0.04	0.07	0.04	0.19	0.25	0.01
MnO	0.22	0.19	0.22	0.23	0.19	0.18
CO_2	1.96	0.80	3.75	2.76	1.19	3.86
H_2O^+	1.99	2.70	3.02	2.56	1.07	3.37
H_2O^-	0.46	0.44	0.47	0.62	0.55	0.62
Total	100.0	98.9	100.4	98.5	98.8	100.7

TABLE 4 CONT'D.

Field Code Sample	6-19-9B 241	6-19-10 242*	6-19-12 243	6-21-1 244*	6-21-4 245	6-21-6 246*
SiO_2	72.1	48.2	47.6	46.4	48.5	46.0
Al_2O_3	17.0	15.3	14.4	15.4	14.4	14.7
Fe_2O_3	0.26	3.10	2.50	3.80	3.40	2.36
FeO	0.77	9.45	10.8	9.37	9.98	5.68
MgO	0.22	5.75	7.88	6.52	6.80	12.0
CaO	0.74	10.3	8.90	11.4	9.77	14.1
Na_2O	3.81	2.37	2.07	1.17	1.64	0.82
K_2O	2.57	0.10	0.12	0.19	0.14	0.02
TiO_2	0.47	1.24	1.38	1.26	0.93	0.43
P_2O_5	0.08	0.06	0.07	0.11	0.09	0.04
S	0.02	0.02	0.01	0.06	0.01	<0.01
MnO	0.05	0.22	0.20	0.22	0.26	0.17
CO_2	0.70	0.83	0.56	0.22	0.67	0.19
H_2O^+	0.77	2.06	2.91	1.90	2.00	1.80
H_2O^-	0.72	0.59	0.55	0.53	0.52	0.43
Total	100.3	99.6	99.9	98.5	99.1	98.7

*Indicates subvolcanic mafic intrusive rock closely associated with the supracrustal rocks.

Field Code Sample	6-21-9 247	6-22-1 248	6-22-2 249	6-27-1 250	6-27-3 251	6-27-4 252
SiO_2	50.0	47.5	44.5	57.6	73.1	47.7
Al_2O_3	20.4	15.5	7.14	15.1	13.9	15.3
Fe_2O_3	2.20	3.36	1.80	2.59	0.39	4.29
FeO	4.38	7.07	10.2	5.61	0.61	9.91
MgO	5.87	5.17	20.8	3.85	0.20	5.38
CaO	8.70	13.1	8.02	4.68	0.26	9.24
Na_2O	3.86	1.46	0.01	4.97	5.29	1.85
K_2O	0.10	0.01	0.01	0.35	3.15	0.07
TiO_2	1.05	0.76	0.47	1.13	0.19	1.32
P_2O_5	0.09	0.08	0.06	0.25	0.02	0.09
S	0.01	0.14	<0.01	<0.01	<0.01	0.12
MnO	0.16	0.26	0.19	0.12	0.02	0.20
CO_2	0.33	2.94	0.29	0.38	0.41	0.32
H_2O^+	2.40	2.00	4.10	1.85	0.15	2.93
H_2O^-	0.44	0.42	0.70	0.63	0.59	0.44
Total	100.00	99.8	98.3	99.1	98.3	99.2

TABLE 4 CONT'D.

Field Code Sample	6-27-7 253	6-27-8 254	6-27-10 255	6-28-1 256	6-28-2 257	6-28-3 258
SiO_2	60.3	55.6	64.8	47.1	46.9	58.3
Al_2O_3	19.7	17.2	15.7	15.1	13.8	15.4
Fe_2O_3	1.01	2.09	1.31	2.76	4.83	1.09
FeO	1.92	6.22	2.61	8.14	11.4	4.38
MgO	0.78	2.90	2.78	6.90	5.11	4.87
CaO	1.51	4.49	2.17	8.04	9.09	3.74
Na_2O	8.71	4.62	3.94	2.60	2.46	5.30
K_2O	1.30	0.60	1.45	0.50	0.93	0.04
TiO_2	1.08	1.54	0.52	0.74	1.97	1.16
P_2O_5	0.20	0.21	0.08	0.04	0.25	0.26
S	<0.01	0.02	<0.01	0.08	0.15	<0.01
MnO	0.05	0.15	0.08	0.18	0.24	0.11
CO_2	1.13	0.80	0.59	4.17	0.08	2.01
H_2O^+	1.14	2.55	1.90	3.76	1.59	2.70
H_2O^-	0.28	0.40	0.40	0.40	0.46	0.33
Total	99.1	99.6	98.3	100.5	99.3	99.7

Wakami River, in the boundary area of Benton and Mallard Townships. This is a greyish rock which is locally sheared, and except for the presence of plagioclase phenocrysts that are locally abundant, is not much different in appearance from calc-alkaline basalt.

Felsic Metavolcanics

Interbeds of felsic metavolcanics are locally found within the mafic metavolcanics of the map area. These interbeds, many of which are too small to be shown on the map, consist mostly of muscovite schist in which primary features have been completely obliterated (Photo 4), and are seldom well exposed. Their composition varies from calc-alkaline rhyolite (Table 4, analyses 60, 163, 166, 168, 251) to calc-alkaline dacite (Table 4, analysis 255). The interbeds are easily recognized because of their yellowy or white colours, and also because they are generally affected by dynamic metamorphism more severely than the mafic metavolcanics enclosing them.

Felsic metavolcanic units of relatively large size are partially exposed in Benton Township and adjacent parts of Garnet Township. In southwestern Benton Township 2 main felsic metavolcanic units are displaced by a fault trending north-northeast (see Map 2504 in back pocket). The parts of these units east of the fault are poorly exposed, and consist of variably sheared pyroclastic rocks containing an estimated 20 to 75 percent clasts; the clasts are up to 40 cm in size, are generally strongly elongated, and consist of dominant felsic metavolcanics with aphanitic to tuffaceous and/or porphyritic textures, and of minor chert. They are embedded in a very light grey groundmass a sample of which proved to be calc-alkaline dacite (Table 4, analysis 187). This groundmass is locally porphyritic. On the west side of the fault, and within a short distance from it, both units are thoroughly sheared and no primary features could be recognized within them. The textural features seen in a few outcrops of the southern unit located about 600 m west of the fault, suggest that in this locality the unit is probably porphyritic. Well exposed and relatively unmetamorphosed outcrops of the northern unit located about 2 km west of the fault, consist of light grey porphyry with composition varying from calc-alkaline rhyolite (Table 4, analyses 108, 110, 112) to calc-alkaline dacite (Table 4, analysis 109). This rock has a fine-grained to aphanitic matrix, and contains scattered to abundant phenocrysts of altered feldspar up to 10 mm in size. In outcrops of the same unit found in eastern Garnet Township 1.8 km west of the locality just mentioned, the phenocrysts are mostly quartz, and the matrix has generally larger grain-size. The grain-size of the matrix is locally such to

Photo 3. Fragment of aphanitic rhyolite with rather angular outline in intermediate pyroclastic metavolcanics; the matrix of the rock (upper left-hand corner) is calc-alkaline basalt (analysis 114). Central Benton Township.

suggest that the rock is of intrusive origin, and this applies also to the northernmost felsic unit in eastern Garnet Township.

Thus, the features present in the main felsic units in the central part of the map area, indicate that the genetic conditions of the rocks in these units vary from (1) subvolcanic, and possibly intrusive, in eastern Garnet Township and adjacent parts of western Benton Township, to (2) pyroclastic in southwestern Benton Township. The transition from condition (1) to condition (2) occurs from west to east along strike of the units; the subvolcanic (i.e. porphyritic) segments of the units, and the fine-grained component of their pyroclastic phases (i.e. matrix), have the same compositional range which is calc-alkaline rhyolite to calc-alkaline dacite. Porphyritic units merging along strike with pyroclastic rocks were also noted in Mallard Township. In this area, however, the porphyritic rocks are calc-alkaline dacite (Table 4, analysis 206) or rhyolite, but the pyroclastic rocks have mafic matrix, and contain clasts of felsic metavolcanics. The porphyritic and pyroclastic rocks are therefore part of different felsic and intermediate units, and were mapped accordingly.

Small felsic metavolcanic units occur interbedded with chert in Cunningham Township (see Map 2503 in back pocket). The contacts of felsic metavolcanics and chert are largely unexposed. The unit with oval outline south of Beavertail

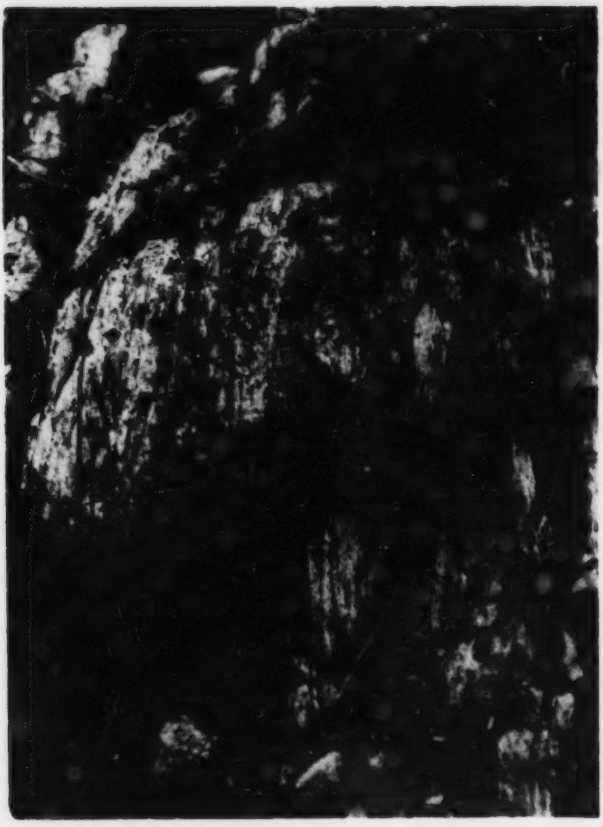

Photo 4. *Felsic metavolcanic interbed in mafic metavolcanics (not visible in photo); the interbed is about 2 m thick and has been reduced to a very fissile muscovite schist by dynamic metamorphism. Southwest shore of Ransom Lake, Cunningham Township.*

Lake is an essentially massive porphyritic rock; in hand specimen and in thin section this rock is very similar to the previously mentioned porphyritic rhyolite found in western Benton Township. It contains subhedral phenocrysts of altered feldspar which are commonly 2 to 6 mm in size, and are found mostly in the central part of the body. The same rock occurs also as dikelets which cut the supracrustal rocks in the general area, and are too small to be shown on the map. These dikelets indicate the intrusive nature of the porphyry with respect to the supracrustal rocks in general. Yet, although the margins of the oval porphyry body are poorly exposed, it is tentatively suggested that the porphyry may in fact grade laterally into chert. This is because in the marginal area of the body the feldspar phenocrysts are lacking or absent, and the matrix tends to become aphanitic and siliceous and is undistinguishable from structureless chert. The apparent "transition" of porphyry into chert may be explained by assuming that the upper part of a subvolcanic porphyritic intrusion was first exposed by submarine erosive processes, and then supplied to the seawater the silica which was subsequently deposited as chert.

An apparently gradual transition into chert was also locally noted along the inferred northern boundary of the longer felsic metavolcanic unit in western

Cunningham Township. Here, however, the widespread metamorphic foliation affecting the unit makes it difficult to recognize its primary features. On account of its textural features and of its narrowness and linear outcrop pattern, the unit is interpreted as a layer of tuffaceous rhyolite interbedded with chert. It may be noted that if this unit is indeed pyroclastic as believed by the writer, then its upward blending with chert is easily understood with no need for further assumptions. At any rate it is suggested that chert could be genetically related to the felsic metavolcanics spatially associated with it, regardless of whether the metavolcanics are of pyroclastic or subjacent origin.

Chemical Composition

Main Elements Data on the chemical composition of 245 samples of metavolcanics from the map area, and of 13 samples of mafic intrusive rocks spatially associated with the mafic metavolcanics, are summarized by the ternary cation plot in Figure 2 (Jensen 1976). The chemical analyses of these samples are given (in weight percent) in Table 4, and are numbered 1 to 258; corresponding location numbers are shown on the maps in the back pocket and Table 2 indicates in which township the location number can be found. Approximately one quarter of the volcanic samples are from Cunningham Township, and the remaining samples are largely from Benton and Mallard Townships in proportion of about 2:1. The samples from Cunningham Township are essentially from the Santimaw Lake area, and represent a cross section of the best exposed metavolcanic sequence found in the map area. The sequence trends west-northwest, is 2800 m thick, and is bounded by epiclastic metasediments to the north, and by a chert unit and intrusive rocks to the south. It consists of tholeiitic basalt which includes iron-rich and magnesium-rich types. The Santimaw Lake tholeiites are assumed to extend eastward into western Garnet Township, on the basis of the similarity between the rocks seen in these localities, and of the continuity in general structural trend through the area. The scarcity and scattered distribution of outcrops over most of Garnet Township prevented systematic sampling of the metavolcanics, and only 5 samples from this township were analyzed (i.e. analyses 105, 106, 107, 173, 174). All the analyzed samples are representative of unmineralized rocks; except for those analyses of the matrix of pyroclastic units that were previously indicated, no samples of intermediate pyroclastic rocks were analyzed.

The main features indicated by the cation plot in Figure 2 are: (a) the presence of a calc-alkaline sequence, (b) the clustering of the tholeiitic basalts at the transition between high-iron and high-magnesium types, and (c) the lack of komatiitic metavolcanics. Because of the general scarcity of outcrops in many parts of the map area, it is virtually impossible to delineate individual tholeiitic versus calc-alkaline sequences at the present scale of mapping. Thus, the 2 types are necessarily grouped together on the accompanying geological maps (back pocket); Figure 3 shows the general distribution of the calc-alkaline metavolcanics in the eastern half of the map area. No significant amounts of calc-alkaline metavolcanics appear to be present in Cunningham Township and western Garnet Township; the distribution of the calc-alkaline metavolcanics in other parts of Garnet Township cannot be outlined on the basis of the present data. Tables 5 to 10 contain 6 sets of 5 chemical analyses each and each set is characteristic of 1 of the following types: iron-rich tholeiitic basalt, magnesium-rich tholeiitic basalt, calc-alkaline basalt, calc-alkaline andesite, calc-alkaline dacite, and calc-alkaline rhyolite. Each set of analyses is regarded as typical in that it plots well within (i.e. far from the boundaries of) the corresponding compositional field in the ternary cation plot in Figure 2. Table 3 gives the chemical composition of a sample from the only outcrop of ultramafic komatiite found in the map area.

Trace Elements The histograms in Figures 4, 5, 6, 7, and 8 show the amounts and distributions of zinc, copper, nickel, cobalt, and chromium in the analyzed samples of metavolcanics. These 245 samples are divided into 5 groups; the groups are designated A, B, C, D, and E compositions which plot in different areas of the ternary diagram in Figure 2. Group A includes 25 samples that plot in the fields of

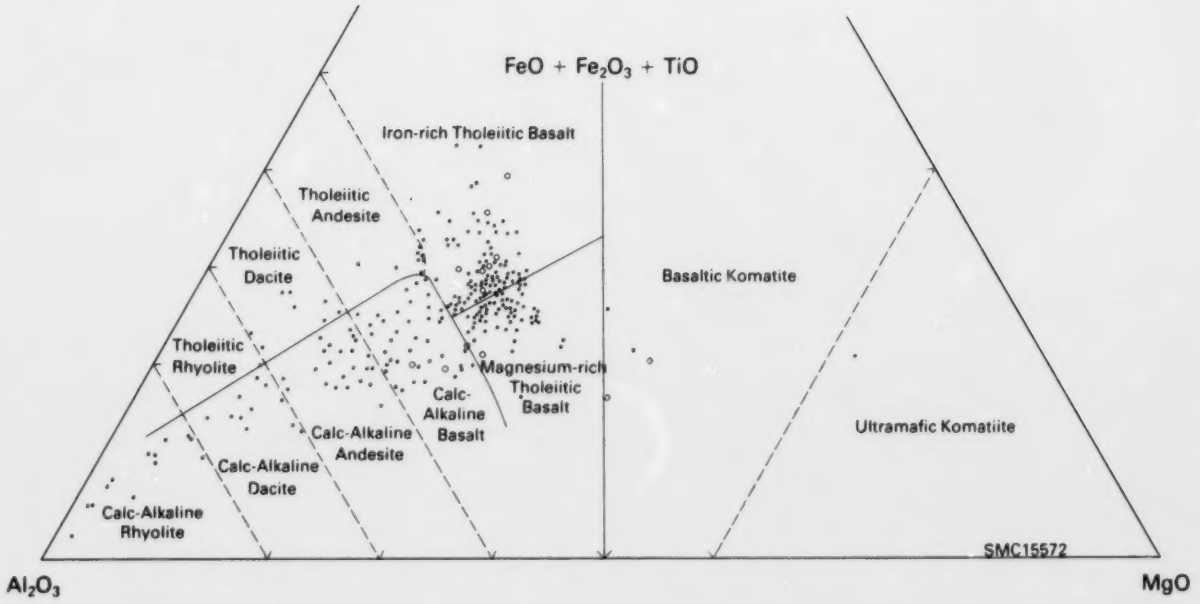

Figure 2. *Jensen cation plot of 245 analyses of metavolcanics (dots) and of 13 analyses of mafic intrusive rocks (circles) from the Garnet Lake Area.*

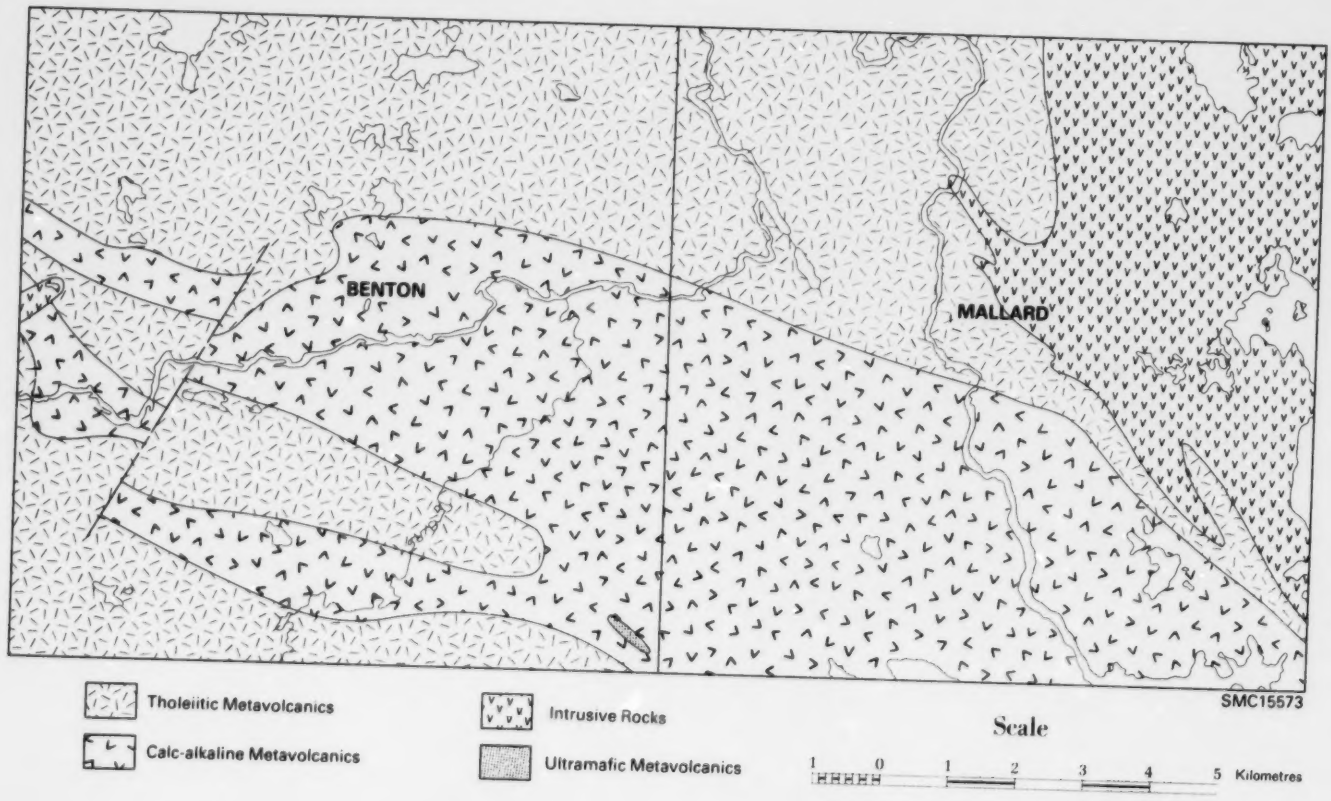

Figure 3. *Sketch map showing the general distributions of tholeiitic and calc-alkaline metavolcanics in Benton and Mallard Townships. The size of the unit of ultramafic metavolcanics is not to scale but is enlarged.*

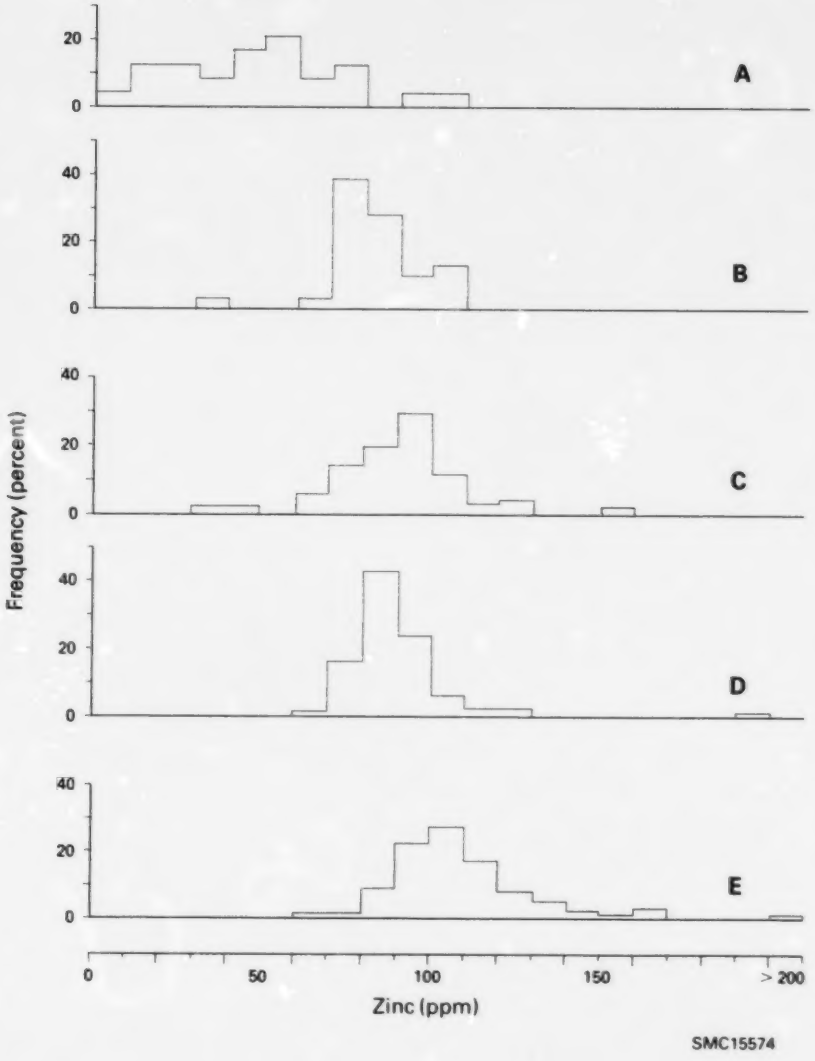

Figure 4. *Histograms of zinc distribution in the metavolcanics of the Garnet Lake Area.*

A *-Calc-alkaline rhyolite and dacite (25 analyses).*
B *-Mostly calc-alkaline andesite (29 analyses).*
C *-Mostly calc-alkaline basalt (48 analyses).*
D *-Magnesium-rich tholeiitic basalt (57 analyses).*
E *-Iron-rich tholeiitic basalt (86 analyses).*

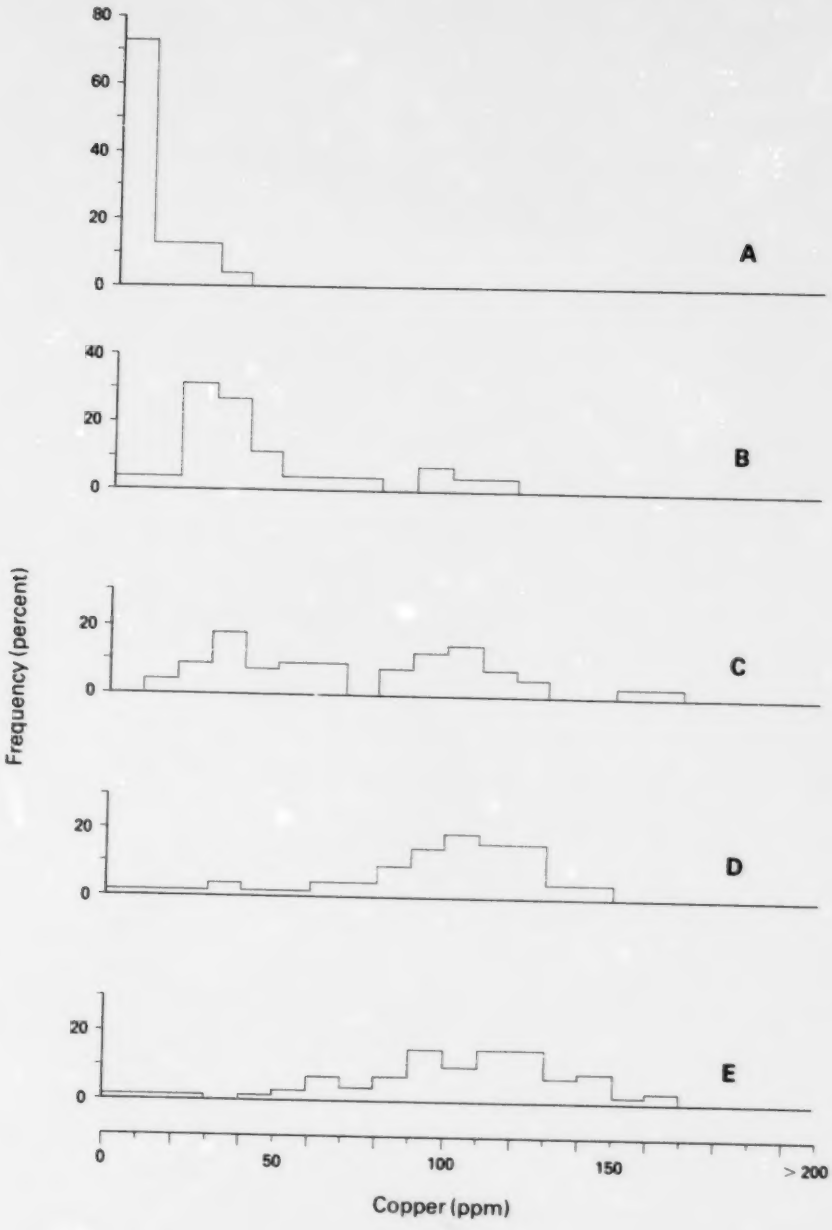

Figure 5. *Histograms of copper distribution in the metavolcanics of the Garnet Lake Area.*

A *-Calc-alkaline rhyolite and dacite (25 analyses).*
B *-Mostly calc-alkaline andesite (29 analyses).*
C *-Mostly calc-alkaline basalt (48 analyses).*
D *-Magnesium-rich tholeiitic basalt (57 analyses).*
E *-Iron-rich tholeiitic basalt (86 analyses).*

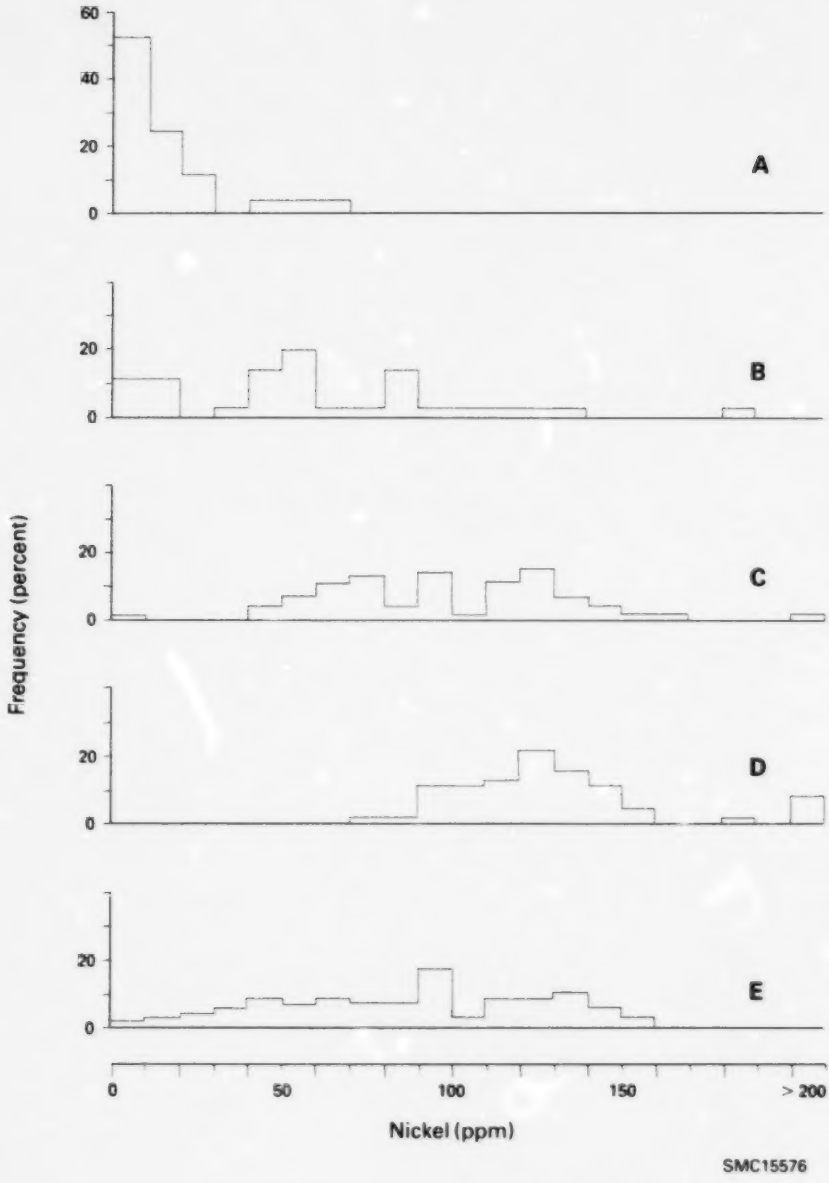

Figure 6. *Histograms of nickel distribution in the metavolcanics of the Garnet Lake Area.*

A *-Calc-alkaline rhyolite and dacite (25 analyses).*
B *-Mostly calc-alkaline andesite (29 analyses).*
C *-Mostly calc-alkaline basalt (48 analyses).*
D *-Magnesium-rich tholeiitic basalt (57 analyses).*
E *-Iron-rich tholeiitic basalt (86 analyses).*

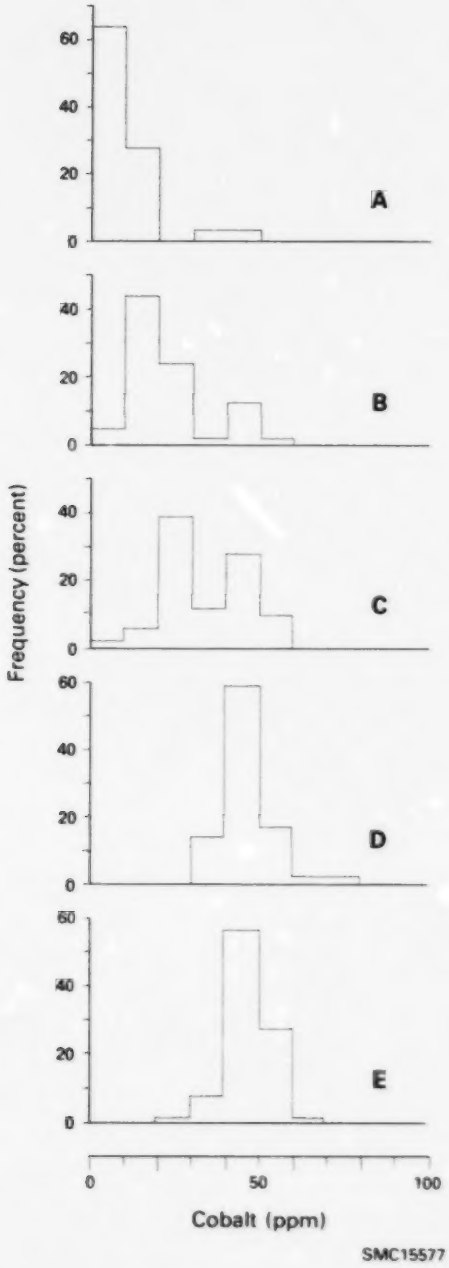

Figure 7. Histograms of cobalt distribution in the metavolcanics of the Garnet Lake Area.

A -Calc-alkaline rhyolite and dacite (25 analyses).
B -Mostly calc-alkaline andesite (29 analyses).
C -Mostly calc-alkaline basalt (48 analyses).
D -Magnesium-rich tholeiitic basalt (57 analyses).
E -Iron-rich tholeiitic basalt (86 analyses).

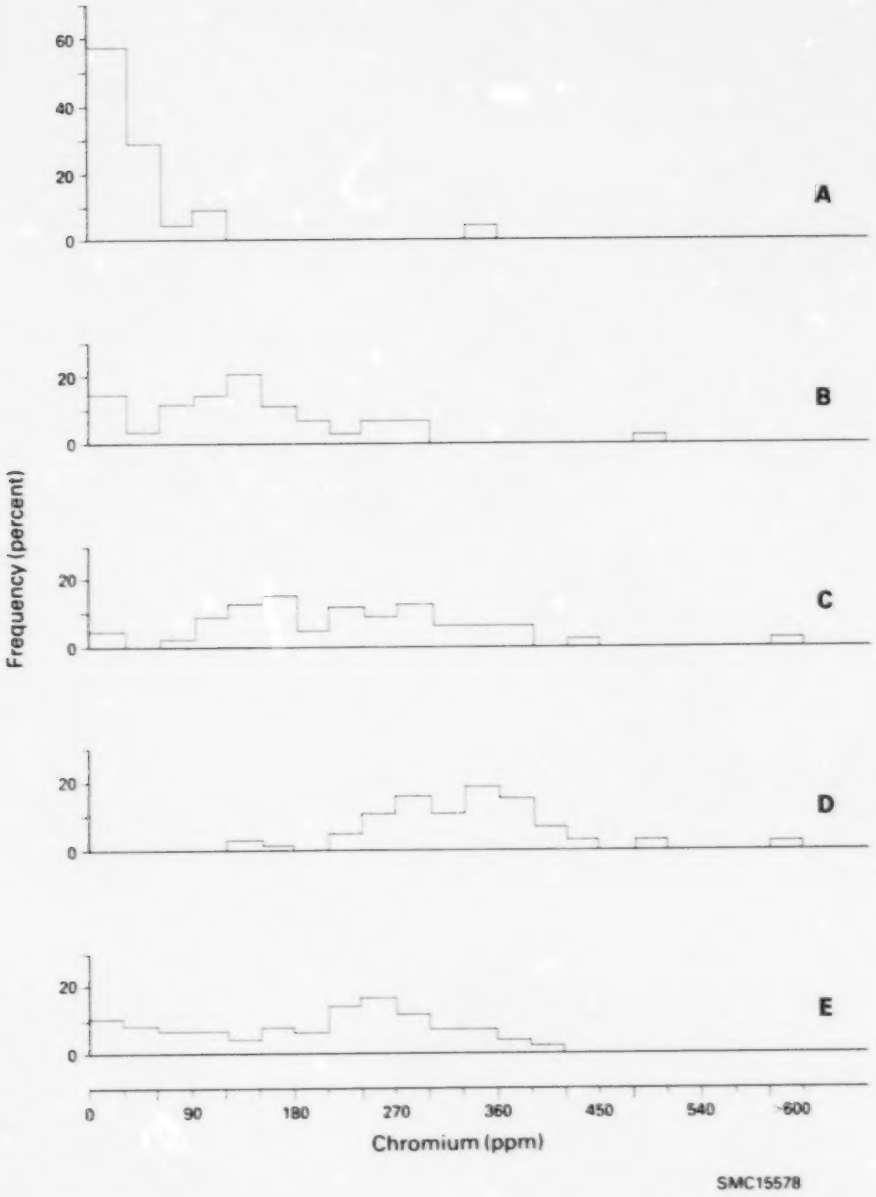

Figure 8. *Histograms of chromium distribution in the metavolcanics of the Garnet Lake Area.*

A *-Calc-alkaline rhyolite and dacite (25 analyses).*
B *-Mostly calc-alkaline andesite (29 analyses).*
C *-Mostly calc-alkaline basalt (48 analyses).*
D *-Magnesium-rich tholeiitic basalt (57 analyses).*
E *-Iron-rich tholeiitic basalt (86 analyses).*

calc-alkaline rhyolite and calc-alkaline dacite, in about equal proportions. Group B contains 31 samples 23 of which plot in the field of calc-alkaline andesite, and the remaining 8 are in the field of tholeiitic dacite; the tholeiitic dacites are grouped together with the andesites in the adjacent calc-alkaline field because, with reference to trace element distribution, the tholeiitic dacites are too few to be significant as an individual group. For the same reason, group C includes 8 samples which plot in the field of tholeiitic andesite, and 40 samples which plot in the field of calc-alkaline basalt. Group D includes 54 samples which plot in the field of magnesium tholeiitic basalt, and 3 samples of komatiitic metavolcanics. Group E includes 86 samples which plot in the field of iron tholeiitic basalt.

Out of the 245 analyzed samples, 19 have lead contents of between 10 and 20 ppm; 14 of these are tholeiites of basaltic to andesitic composition, 3 are calc-alkaline basalt, and 2 are calc-alkaline andesite. A few of the remaining 226 samples have lead content of 10 ppm, but the large majority of them contains less than 10 ppm lead. The amounts of trace elements found with higher frequency in calc-alkaline andesite are consistently larger than those in calc-alkaline rhyolite and dacite. For example, 70 to 80 ppm zinc and 20 to 30 ppm copper are most frequent in calc-alkaline andesite (Figures 4B, 5B), whereas 50 to 60 ppm zinc and up to 10 ppm copper are the most frequent ranges in calc-alkaline rhyolite and dacite (Figures 4A, 5A). The spread of the zinc distribution in calc-alkaline rhyolite and dacite is also evident, as the distributions of the other trace elements in these rocks have prominent frequency peaks in the 0 to 10 ppm class interval.

The histograms of group C show that 60 to 110 ppm zinc, 40 to 150 ppm nickel, 10 to 60 ppm cobalt, and 60 to 390 ppm chromium are of common occurrence in the calc-alkaline basalt of the map area. These histograms are also likely to reflect to some extent the scarcity of data, but particularly those of copper and cobalt suggest bimodal distributions; the 2 frequency peaks in the distribution of copper are in the 30 to 40 ppm and 100 to 110 ppm class intervals (Figure 5C), and those of cobalt are in the 20 to 30 ppm and 40 to 50 ppm class intervals (Figure 7C).

The histograms of groups D and E show that copper and cobalt have similar distributions in magnesium-rich and iron-rich tholeiitic basalts; the copper values are mostly 50 to 150 ppm with high frequencies in the 90 to 130 ppm class intervals (Figures 5D, 5E), and the cobalt values are essentially 30 to 60 ppm with peak frequency in the 40 to 50 ppm class interval (Figures 7D, 7E). In magnesium-rich tholeiitic basalt most zinc values are between 70 and 110 ppm with a marked frequency peak in the 80 to 90 ppm class interval; in iron-rich tholeiitic basalt most zinc values are between 80 and 140 ppm with a frequency peak in the 100 to 110 ppm class interval (Figures 4D, 4E). In magnesium-rich tholeiitic basalt the chromium values are mostly between 210 and 450 ppm with higher frequencies in the 270 to 300 ppm and the 330 to 390 ppm class intervals (Figure 8D); the nickel values are mostly between 90 and 160 ppm with peak frequency in the 120 to 130 pm class interval (Figure 6D). In iron-rich tholeiitic basalt the chromium values are spread between less than 10 ppm and 420 ppm with higher frequencies in the 210 to 300 ppm range, and in the range of less than 10 ppm to 60 ppm (Figure 8E); the nickel values are also spread essentially between 10 and 150 ppm with a marked frequency peak in the 90 to 100 ppm class interval (Figure 6E). These data clearly indicate that magnesium-rich tholeiitic basalt contains less zinc, but more chromium and nickel than iron-rich tholeiitic basalt.

The present data on zinc distribution are in general agreement with recently published data on zinc distribution in Precambrian volcanics of the Superior Province (Wolfe 1977, p.28). Also, the range in copper content of tholeiitic basalt in the present map area (i.e. 50 to 150 ppm), is the same range found by Wolfe in basalt and andesite in the Ben Nevis Township area (Wolfe 1977, p.16). Analyses of rhyolitic to basaltic volcanics are grouped together in Wolfe's histograms, and because of this the comparison of the Ben Nevis data with those of the present map area can be done only in a general fashion. The histogram of nickel distribution in the Ben Nevis volcanics shows a frequency peak in the 80 to 90 ppm range (Wolfe 1977, Figure 14, Chart A); a marked frequency peak at this same

range is found in calc-alkaline andesites of the present map area (Figure 6B). As previously noted, higher nickel values occur in basalt, and particularly in magnesium-rich tholeiitic basalt. The histogram of cobalt distribution in the Ben Nevis volcanics shows a frequency peak in the 20 to 25 ppm range (Wolfe 1977, Figure 18, p.20); a comparable frequency peak in the 20 to 30 ppm range is found in calc-alkaline basalts of the present map area (Figure 7C). However, the cobalt distribution in the tholeiitic basalts of the present map area is characterized by a prominent frequency peak in the 40 to 50 ppm range (Figures 7D, 7E), which is exactly twice the range with highest frequency in the Ben Nevis volcanics.

Microscopic Description

Ultramafic Komatiite A thin section of 1 specimen of this rock (specimen 6-22-2, see section "Mafic Metavolcanics" and Table 3) shows that it consists of a cryptocrystalline aggregate of chlorite containing subordinate amounts of altered tiny flakes of amphibole believed to be tremolite, and accessory iron oxides. An X-ray analysis of the rock has not revealed components other than the above (Ontario Geological Survey analysis C-20407).

Tholeiitic Basalt Four textural types are present and differ from one another in details rather than prominent features. The dominant feature common to all types is the presence of a dense aggregate of cryptocrystalline to microcrystalline chlorite with lesser epidote and carbonates, and accessory iron oxides, iron sulphides, and leucoxene. The aggregate of chlorite, epidote, and carbonates is cloudy and uniform in appearance, and most of the accessory minerals are larger than the individual microlites in the aggregate; measurable microlites of chlorite and epidote have mostly sizes of 0.002 to 0.010 mm. This chloritic aggregate or groundmass may contain a few small microphenocrysts of plagioclase that are commonly thoroughly replaced by alteration products, and ovoid amygdules filled by 1 or more among zoisite, carbonates, and (rare) quartz. The latter minerals, and particularly carbonates which may show well developed polysynthetic twinning, are also present as fracture-filling material. The amygdules are generally less than 0.5 mm in size, and seem to occur more frequently in iron-rich tholeiitic basalt. The first and largely dominant textural type is characterized by no other features than the ones just described.

The second textural type is determined by the presence of large, although poorly defined, flaky aggregates of chlorite up to 1.6 mm in size. Although some of these aggregates may be elongated to variable extents depending upon the intensity of metamorphic foliation, in general they do not show preferred orientation. The chlorite in local areas of some aggregates is pseudomorphic after clinopyroxene.

The third textural type is characterized by scattered to locally abundant plagioclase microlites which are commonly 0.004 to 0.032 mm wide and up to 0.57 mm long. The microlites are generally randomly oriented; in a few sections they show fluidal texture, and in local areas of sections where they are particularly abundant they show pilotaxitic texture. These microlites are too small and altered to permit identification of the plagioclase composition. In 1 thin section containing relatively large microlites the plagioclase composition was found to be oligoclase (An_{22}, specimen 5-18-4). The textural type just described was more frequently found in magnesium-rich tholeiitic basalt.

The fourth textural type is rare and was found only in iron-rich tholeiitic basalt. It consists of subhedral chloritized clinopyroxene crystals and carbonatized calcic plagioclase laths up to 1.3 mm in length, embedded in the chlorite-epidote-carbonates groundmass previously described (specimen 3-21-3). The plagioclase laths are randomly oriented and are probably labradorite (An_{66}). Except for the presence of the microcrystalline groundmass, this texture is similar to that of diabase.

Only 1 out of the 101 thin sections of tholeiitic basalt that were examined was found to be recrystallized (specimen 3-27-3). This basalt is of the iron-rich type, and consists essentially of equant hornblende crystals 0.06 to 0.2 mm in size. It

TABLE 5. CHEMICAL ANALYSES OF TYPICAL IRON-RICH THOLEIITIC BASALT (WEIGHT PERCENT).

Sample*	29	157	165	196	257
SiO_2	46.30	48.90	49.20	51.40	46.90
Al_2O_3	14.30	13.50	12.80	14.30	13.80
Fe_2O_3	3.10	4.30	5.10	2.83	4.83
FeO	12.20	10.90	12.10	10.50	11.40
MgO	5.48	6.11	3.93	6.22	5.11
CaO	10.70	8.00	8.49	4.08	9.09
Na_2O	1.39	3.40	2.36	2.16	2.46
K_2O	0.01	0.07	0.33	0.00	0.93
TiO_2	1.13	1.37	1.83	1.81	1.97
P_2O_5	0.10	0.13	0.21	0.16	0.25
S	0.02	0.05	0.15	0.18	0.15
MnO	0.22	0.24	0.26	0.24	0.24
CO_2	0.64	0.11	0.24	1.55	0.08
H_2O^+	2.66	2.44	2.28	4.61	1.59
H_2O^-	0.31	0.52	0.34	0.72	0.46
Total	98.6	100.0	99.6	100.8	99.3

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

TABLE 6. CHEMICAL ANALYSES OF TYPICAL MAGNESIUM-RICH THOLEIITIC BASALT (WEIGHT PERCENT).

Sample*	32	105	186	195	219
SiO_2	49.50	49.10	50.10	47.70	53.90
Al_2O_3	14.80	14.80	15.90	15.70	13.40
Fe_2O_3	1.60	1.70	1.67	2.30	2.21
FeO	9.34	10.10	8.76	8.91	7.37
MgO	8.40	8.47	8.41	8.07	8.97
CaO	9.70	7.11	7.37	8.86	5.21
Na_2O	2.86	2.75	1.99	1.00	2.26
K_2O	0.34	0.03	1.24	0.02	0.32
TiO_2	0.73	0.90	0.78	0.82	0.77
P_2O_5	0.05	0.04	0.05	0.05	0.15
S	0.05	0.11	0.04	0.02	0.01
MnO	0.21	0.19	0.19	0.22	0.17
CO_2	0.18	1.04	0.30	1.04	0.26
H_2O^+	1.35	3.22	2.11	3.10	3.11
H_2O^-	0.27	0.33	0.71	0.69	0.79
Total	99.4	99.9	99.6	98.5	98.9

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

TABLE 7. CHEMICAL ANALYSES OF TYPICAL CALC-ALKALINE BASALT (WEIGHT PERCENT).

Sample*	46	172	197	214	258
SiO_2	52.20	59.00	57.00	62.10	58.30
Al_2O_3	16.40	15.00	16.10	13.80	15.40
Fe_2O_3	1.63	1.79	1.37	1.63	1.09
FeO	7.16	4.78	5.07	4.92	4.38
MgO	5.05	4.16	5.31	4.26	4.87
CaO	6.42	8.44	5.33	3.07	3.74
Na_2O	3.03	3.39	3.98	5.82	5.30
K_2O	0.58	0.04	1.18	0.41	0.04
TiO_2	1.00	0.80	0.87	0.99	1.16
P_2O_5	0.07	0.10	0.23	0.22	0.26
S	0.02	0.09	0.01	0.08	0.01
MnO	0.20	0.14	0.11	0.09	0.11
CO_2	2.30	0.42	0.31	0.49	2.01
H_2O^+	3.34	1.05	1.98	1.31	2.70
H_2O^-	0.39	0.30	0.56	0.90	0.33
Total	99.8	99.5	99.4	100.1	99.7

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

contains an estimated volume of 12 percent untwinned feldspar(s), and minor quartz, chlorite, and opaque minerals.

Calc-Alkaline Basalt The single prominent feature revealed by examination of 33 thin sections of calc-alkaline basalt is its greater plagioclase content relative to tholeiitic basalt. Estimated volumes of 10 to 30 percent plagioclase occur in most thin sections, and volumes of up to estimated 45 percent plagioclase were noted in a few of them. Plagioclase is present as groundmass component and as randomly oriented euhedral phenocrysts with common sizes of 0.05 to about 1 mm. The cores of the phenocrysts may be cloudy owing to inclusions of cryptocrystalline alteration products and iron oxides, and the outlines of the cloudy cores tend to parallel very accurately the outlines of the crystals (specimens 5-20-3, 4-20-12, 4-13-100). Although plagioclase is invariably altered to some extent by carbonatization and/or sericitization, thoroughly altered phenocrysts are relatively rare in comparison with the plagioclase in tholeiitic basalt. This, together with the fact that in many of the sections of calc-alkaline basalt the plagioclase is oligoclase (An_{20-22}), indicates that the plagioclase in calc-alkaline basalt is generally more sodic than in tholeiitic basalt. In this respect it may also be noted that the Na_2O content in the analyses of tholeiitic basalt of Tables 5 and 6 varies between 1.00 and 3.40 weight percent, whereas it varies between 3.03 and 5.82 weight percent in the analyses of calc-alkaline basalt of Table 7. As a groundmass component in the calc-alkaline basalt plagioclase is associated with 1 or more among chlorite (dominant), sericite, carbonates, zoisite, quartz, iron oxides, pyrite, and muscovite which may be locally abundant (specimen 4-18-12).

Calc-Alkaline Andesite Porphyritic texture is characteristic of calc-alkaline andesite, dacite, and rhyolite, and is best developed in the latter 2. In 20 thin sections of calc-alkaline andesite the texture and mineralogical composition of the groundmass were found to be the same as in basalt (see above). The phenocrysts may be up to 1.8 mm in size and consist of plagioclase laths (andesine ?) which are generally euhedral and strongly altered, and subordinately of quartz. Pilotaxitic plagioclase microlites in the chloritic groundmass are rarely present (specimen 6-19-6).

Calc-Alkaline Dacite and Rhyolite These rocks are invariably porphyritic and very similar in thin section. In 11 sections of calc-alkaline dacite and 11 sections of calc-alkaline rhyolite the groundmass was seen to consist of (1) dominant altered feldspars, (2) subordinate muscovite, carbonates, and lesser quartz, and (3) accessory chlorite, epidote, pyrite, magnetite, and (rare) leucoxene and biotite. The groundmass is commonly microcrystalline or cryptocrystalline and may display flow texture owing to statistically linear arrangements of the opaque minerals and of aggregates of muscovite microlites (specimen 4-24-3). The phenocrysts consist dominantly of feldspars and to a lesser extent of quartz, and may be up to 2.7 mm in size. The feldspathic phenocrysts are generally altered enough to prevent identification of the composition; scanty measurements from a few thin sections gave compositions varying from albite to andesine (An_{34}, specimen 5-24-7). The quartz phenocrysts have general rounded or oval outlines indicative of magmatic corrosion, are unstrained, and contain tiny inclusions of muscovite and/or chlorite. The rounded outlines of the quartz phenocrysts, and the predominance of quartz-feldspathic components and of muscovite in the groundmass, are the main features distinguishing these rocks from porphyritic calc-alkaline andesite.

The examined sections are representative of relatively unmetamorphosed rocks and the only primary feature consistently found in these is the porphyritic texture. Because the feldspar phenocrysts may in a few sections be interpreted as fragments of (formerly) larger crystals, the possibility that some of these rocks are crystal tuff cannot be excluded. Nevertheless, because in the writer's experience lithic fragments are invariably present in "crystal" tuffs and no such fragments were found in the sectioned rocks, the possibility that some of the latter are pyroclastic in origin is considered an unlikely one.

SUBVOLCANIC INTRUSIVE ROCKS

Mafic Intrusive Rocks

General Character Gabbroic intrusions form separate bodies underlying large areas in the southwestern, central, and eastern parts of the map area.

These gabbroic rocks may be generally described as massive, medium- to coarse-grained rocks, and have greenish grey to dark green colour, depending on

TABLE 8. CHEMICAL ANALYSES OF TYPICAL CALC-ALKALINE ANDESITE (WEIGHT PERCENT).

Sample*	61	126	141	176	207
SiO_2	57.60	57.70	59.20	66.44	60.70
Al_2O_3	16.60	15.90	15.90	14.70	15.70
Fe_2O_3	2.89	1.91	2.22	0.01	1.77
FeO	4.40	4.88	5.07	6.68	4.30
MgO	3.34	5.58	5.31	2.45	3.43
CaO	7.55	6.40	1.71	1.92	2.52
Na_2O	1.20	2.43	4.72	1.68	5.62
K_2O	3.07	1.11	0.22	1.18	1.10
TiO_2	0.92	0.70	0.96	0.72	0.66
P_2O_5	0.08	0.15	0.23	0.06	0.11
S	0.01	0.01	0.01	0.14	0.02
MnO	0.15	0.12	0.11	0.08	0.10
CO_2	0.44	0.30	0.13	1.40	0.59
H_2O^+	1.34	1.93	2.80	2.32	1.73
H_2O^-	0.49	0.61	0.64	0.60	0.58
Total	100.0	99.7	99.2	100.3	98.9

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

TABLE 9. CHEMICAL ANALYSES OF TYPICAL CALC-ALKALINE DACITE (WEIGHT PERCENT).

Sample*	128	152	187	209	255
SiO_2	65.50	64.90	66.20	60.80	64.80
Al_2O_3	17.60	16.10	16.80	16.50	15.70
Fe_2O_3	1.78	1.23	0.84	1.26	1.31
FeO	2.76	2.53	4.07	3.15	2.61
MgO	1.74	1.96	1.72	1.99	2.78
CaO	0.66	2.61	1.32	3.14	2.17
Na_2O	6.43	5.03	5.84	6.53	3.94
K_2O	0.61	0.76	0.14	0.95	1.45
TiO_2	0.54	0.49	0.58	0.58	0.52
P_2O_5	0.13	0.11	0.12	0.09	0.08
S	0.01	0.01	0.12	0.01	0.01
MnO	0.02	0.06	0.07	0.08	0.08
CO_2	0.42	2.13	0.58	2.47	0.59
H_2O^+	1.60	1.26	1.33	1.16	1.90
H_2O^-	0.59	0.62	0.51	0.67	0.40
Total	100.4	99.8	100.2	99.4	98.3

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

TABLE 10. CHEMICAL ANALYSES OF TYPICAL CALC-ALKALINE RHYOLITE (WEIGHT PERCENT).

Sample*	108	163	200	222	241
SiO_2	67.90	77.80	70.00	73.00	72.10
Al_2O_3	16.60	15.00	15.80	14.80	17.00
Fe_2O_3	0.81	0.01	0.31	0.54	0.26
FeO	2.30	0.31	1.15	1.23	0.77
MgO	0.78	0.18	0.34	0.30	0.22
CaO	1.43	0.19	1.98	0.77	0.74
Na_2O	5.85	1.57	4.78	4.60	3.81
K_2O	1.14	1.46	1.70	1.32	2.57
TiO_2	0.45	0.29	0.44	0.17	0.47
P_2O_5	0.10	0.06	0.12	0.01	0.08
S	0.01	0.01	0.01	0.01	0.02
MnO	0.04	0.01	0.27	0.03	0.05
CO_2	1.37	0.18	1.46	0.91	0.70
H_2O^+	1.48	1.43	1.00	0.66	0.77
H_2O^-	0.38	0.40	0.30	0.59	0.72
Total	100.6	98.9	99.7	98.9	100.3

*Sample number located on Geological Maps (back pocket)
See Table 2 for township location

a variable mafic content of about 30 to 65 percent in volume. These rocks display textural variations which may be locally conspicuous, but, in the present writer's opinion, such variations do not reflect significant changes in composition. Meen was apparently of a different opinion as he described these rocks as follows (Meen 1944, p.14,15):

"In a number of places in the area, particularly in Garnet and Cunningham townships, there are bodies of what appears to be intrusive rocks of a basic nature. These bodies are irregular in shape and have a maximum length of 2 1/2 miles. In general, the rock is coarse in texture and ranges in colour from light-grey to dark-green. The mineralogical composition and texture vary so much that granodiorite, quartz diorite, diorite, quartz gabbro, gabbro, quartz diabase, and diabase were recognized not only under the microscope but in the field. These variations sometimes occur even within one outcrop."

The circles in the ternary plot of Figure 2 represent chemical analyses of 13 samples of mafic intrusive rocks from various localities of the map area. The analyzed rocks include 6 samples with an estimated mafic content of less than 50 percent in volume, and 7 samples with estimated mafic content greater than 50 percent in volume; in the field the former were mapped as diorite, and the latter as gabbro. This criterion, empirical as it may be, is probably rather commonly used by geologists, as indicated by the statement (American Geological Institute 1980, p.176): "In typical diorite,...mafic minerals total less than 50% of the rock". Because the plots of the analyzed rocks fall essentially in the basaltic fields, and because the general terms "basalt" and "gabbro" are compositionally equivalent, it is evident that these rocks are of gabbroic composition. Had a larger number of samples been analyzed, quite possibly some analyses would have plotted in either or both of the 2 andesitic fields, in which case the mafic intrusive rocks would have been better described as dioritic to gabbroic in composition. Nevertheless, on the basis of the present data, the writer is inclined to think that the variations in texture and colour index of the mafic intrusive rocks are rather deceptive, and that these rocks have largely the composition of gabbro.

The contact relationships of gabbro and metavolcanics are of 3 types characterized by: (1) gradational transition of aphanitic basalt into mediumto coarse-grained gabbro, (2) presence of basaltic xenoliths in gabbro, and (3) presence of gabbro xenoliths in basalt (Photo 5). In the initial stage of field mapping the contact relationships of type (1) were generally interpreted by assuming that the coarse rocks merging into aphanitic basalt were inner parts of lava flows. However,

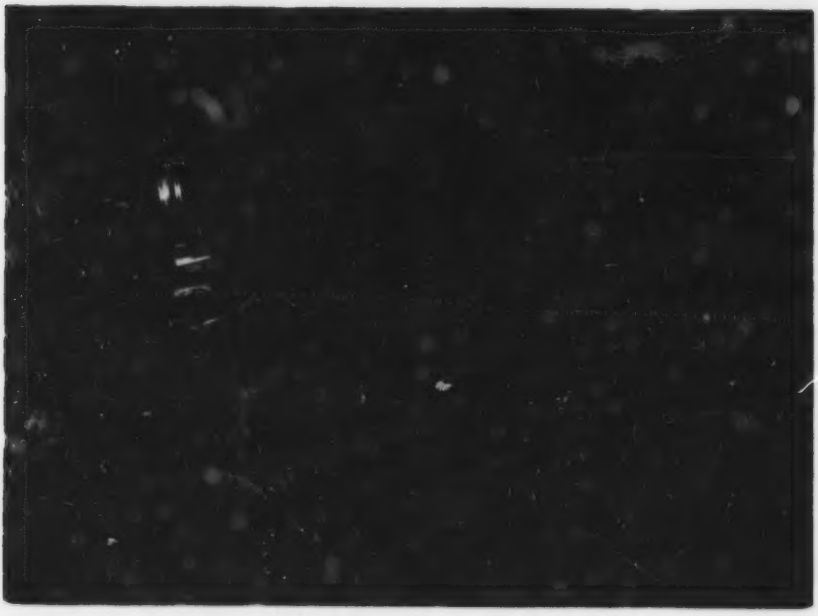

Photo 5. *Blocks of gabbro in basaltic lava. Travel Lake area, Garnet Township.*

as mapping progressed it became apparent that the size and volume of individual gabbroic bodies are much too large to let one regard the above assumption as valid and, in addition, this assumption fails to provide an explanation for contact relationships of types (2) and (3). Therefore, in the writer's opinion, there is little doubt that the bulk of the medium- to coarse-grained gabbroic rocks are of intrusive origin. Meen (1944) was apparently of a different opinion, as many outcrops mapped as gabbro by the writer were mapped by him as mafic volcanics. It would appear, therefore, that he decided that these rocks were coarse-grained volcanics although he did state that they "...appear to be intrusive rocks of a basic nature" (see quote above). These intrusive rocks are regarded as the loci of former magmatic chambers, which were the feeders of basaltic flows that developed wherever suitable conditions occurred in the evolution of the volcano-plutonic edifice. This edifice is envisaged as a continuum, and thus the contact relationships of type (1) are interpreted as evidence of an igneous domain of transition from plutonic to volcanic conditions. The contact relationships of type (2) are interpreted as evidence of roof-foundering of volcanics above magmatic chambers. The contact relationships of type (3) are interpreted by suggesting that magma which crystallized either in upper apophyses of magmatic chambers or along fractures radiating outward of these was locally fractured and engulfed by subsequent basaltic eruptions. In synthesis, it is suggested that: (a) gabbro and basalt are in broad terms time-equivalent, and (b) the contact relationships of gabbro and basalt reflect differences in the depth at which the present erosional surface intersects the former volcano-plutonic edifice.

Microscopic Description Only 3 thin sections of gabbro were examined (specimens 5-9-5, 5-10-1, 6-5-1b). The rock is altered and consists dominantly of clinopyroxene, and subordinate plagioclase. Clinopyroxene (augite ?) accounts for an estimated 60 to 70 percent of the rock in volume, and occurs as randomly oriented crystals which are up to 2 mm in length, and are variably altered by 1 or more among pseudomorphic hornblende, chlorite, and (rare) tremolite. Plagioclase, which is probably andesine or labradorite, is very altered and generally finer grained than, and interstitial to the, clinopyroxene crystals. Common accessory minerals are quartz, leucoxene, hematite, and pyrite, and the rare ones are zircon, apatite, and ilmenite. Quartz occurs mostly as small individual crystals scattered throughout the rock, but also as rare and poorly defined myrmekitic intergrowths with plagioclase.

Ultramafic Intrusive Rocks

General Character Peridotite occurs as relatively small and discrete intrusions exposed at a few localities of southern Cunningham Township, and at 1 locality in the extreme northwestern part of Benton Township. The log of a drillhole drilled by Noranda Exploration Limited in 1977 at another locality in west-central Benton Township indicates the presence of peridotite under about 11 m of overburden, 1060 m south of the Wakami River (see Map 2504, back pocket). Although in some areas of Cunningham Township outcrops of peridotite and gabbroic rocks occur only a few metres apart, the writer was unable to find exposed contacts between peridotite and gabbro.

Peridotite is a relatively soft, bluish black dense rock which is variably serpentinized, generally magnetic, and weathers to red-brown hues. Typically these hues penetrate the rock for only 1 or 2 mm, and the trace of the surface separating the weathered and fresh parts of the rock is a very sharp line. In rare outcrops affected by widespread carbonatization, the rock consists of a slightly friable structureless mass of uniform light grey colour on both the fresh cut and the weathered surface. A characteristic feature of peridotite is the presence of subparallel short fractures perpendicular, or nearly so, to some of the main cooling fractures found in the rock (Photo 6). Neither set of fractures appears to offset the other, but some of the main fractures show deuteric alteration rims which are absent in the short fractures. The short fractures are therefore likely to be the younger features developed when cooling of the rock was almost completed.

Photo 6. *Cooling joints in peridotite. Southwestern Cunningham Township.*

Microscopic Description

Of the 6 thin sections that were examined, 4 have an estimated carbonate content of 6 to 20 percent in volume. These variations in carbonate content are hardly apparent in the 4 hand specimens, since all of these have the same bluish black colour. The remaining 2 sections were cut from samples of grey peridotite, and contain an estimated volume of carbonate of 60 to 70 percent. Idiomorphic crystals of serpentinized olivine which have sizes of 0.23 to 2.2 mm and are equant or polygonal in outline, are the largely dominant component of bluish black peridotite. These crystals are replaced dominantly by pseudomorphic antigorite, which is present as aggregates of flaky or fibro-lamellar structure, and subordinately by 1 or more among carbonate (magnesite ?), chrysotile, and magnetite. In the least carbonatized samples of bluish black peridotite (specimens 5-4-14, 5-5-12), the boundaries of the (former) olivine crystals are sharply defined, and the antigorite aggregates, which have thoroughly replaced olivine, are essentially flaky in structure. The sharpness of the crystal boundaries results from segregation of secondary magnetite along the periphery of the crystals; similar segregations of magnetite occur also along small fractures within individual crystals, but relatively long fractures which cross several crystals are generally filled by chrysotile. In the samples of bluish black peridotite with higher carbonate content (specimens 4-2-5, 5-4-5), the boundaries of many crystals of (former) olivine are poorly defined, and olivine is replaced by 1 or more among (1) aggregates of unidentified serpentine microlites which are dominantly fibro-lamellar in structure, (2) microcrystalline carbonate(s), and (3) magnetite. A few relics of a mineral with upper second-order birefringence which was tentatively identified as clinopyroxene, occur in 1 of these samples (specimen 4-2-5). One of the two samples of altered peridotite of grey colour (specimen 4-2-6), consists of the above components (2), (1), and (3) in this order of decreasing abundance. Local areas of the thin section of this sample contain relics of olivine, which is revealed by the presence of aggregates of relatively large antigorite flakes, and of clinopyroxene. The most intensely altered sample of grey peridotite (specimen 4-2-7), is a fine-grained rock consisting of components (2) and (1) in this order of decreasing abundance; scattered magnetite phenocrysts which are up to 0.46 mm in size, account for about 5 percent in

volume of the rock, but apart from these the rock is texturally homogeneous, and contains no recognizable relics of olivine or pyroxene.

METASEDIMENTS

Metasediments represent a small part of the supracrustal rocks underlying the map area, and include epiclastic and cherty units. The epiclastic metasediments consist of variably sheared polymictic conglomerate found in a few scattered localities in the western half of the map area. The cherty units are found mostly in central Cunningham Township.

Epiclastic Metasediments

Conglomerate General character of the conglomerate consists of pebbles and boulders of metavolcanics which are mostly felsic, fine-grained clastic metasediments, chert-magnetite ironstone, and equigranular to porphyritic sodic granitoid rocks, embedded in a gritty heterogeneous matrix of greyish brown colour. Generally the cross sections of the clasts have elongated elliptical outlines, and, due to deformation, the clasts appear to be closely packed together. Most outcrops of the conglomeratic unit north of the Wakami River in northwestern Cunningham Township are strongly sheared, and because of this the outlines of individual clasts may be recognized only locally. A relatively unmetamorphosed small unit of conglomerate is exposed along the southern shore of Travel Lake in west-central Garnet Township. This conglomerate is matrix-supported and contains boulders with cross sections up to 80 cm in length (Photos 7, 8).

Microscopic Description A thin section of conglomeratic matrix from a relatively undeformed outcrop located on the northern side of the Wakami River (Cunningham Township), shows bimodal distribution in the size of the components (specimen 3-3-16). About 90 percent in volume of the rock is a cloudy cryptocrystalline to microcrystalline groundmass which is dominantly feldspathic and contains accessory amounts of chlorite and hematite, and traces of muscovite. An estimated 10 percent in volume of the rock consists of subangular to rounded grains of dominant quartz and subordinate albitic plagioclase which are 0.15 to 0.54 mm in size. The effects of dynamic metamorphism are evident in many of these grains which are fractured and/or strained, and show evidence of rotation and slip at the interface with the finer grained groundmass, but virtually no metamorphic recrystallization has affected this rock.

Chemical Metasediments

General Character Chert is commonly laminated to medium-bedded, white to almost black in colour, and contains variable amounts of magnetite ironstone. Outcrops shown as "ironstone" on the accompanying maps (in back pocket) are those in which the estimated cumulative thickness of magnetic laminae or beds, is about 50 percent or more of the exposed thickness of the rock. The criterion is not accurate but permits a quick distinction of chert-ironstone of potential economic interest from ferruginous or barren chert mapped by previous workers as "Iron Formation".

In Cunningham Township, the cherty units form relatively continuous ridges the most prominent of which is located south of Beavertail Lake. These units are in the middle section of the southwest-facing sequence of tholeiitic basalt underlying the area, are deformed by folding, faulting, and emplacement of intrusive rocks, and are locally the hosts of base metal sulphide mineralization. The contact relationships of the cherty units with the mafic intrusive rocks have a bearing on considerations of an economic nature (see section "Recommendations for Prospectors"). In the writer's opinion the cherty unit south of Peter Lake is a former western segment of the prominent hook-shaped unit in the central part of Cunningham Township, which had been displaced to its present position by a fault trending north-northwestward (i.e. Isaiah Creek Fault). Similarly, the cherty units to the southeast of the hook-shaped unit, are regarded as remnants of a former

Photo 7. Relatively unmetamorphosed polymictic conglomerate cut by small diabase dikelet. Southern shore of Travel Lake, west-central Garnet Township.

eastern lobe of the latter, which was intruded and partially obliterated by emplacement of the mafic intrusive rocks underlying the area. The unusual outline of the hook-shaped unit, is the result of folding in the eastern side of it. Folding has also caused widespread brecciation characterized by fracturing and rotation of the fragments through the bedding plane. In outcrops affected by relatively little brecciation former continuous layers are still recognizable as linear arrays of displaced fragments of the same lithology. Where fracturing and rotation of fragments have occurred extensively, as in areas of high curvature of folds, the rock is a chaotic mixture of dominantly angular fragments of chert and ironstone in which evidence of bedding has been thoroughly obliterated.

Sphalerite and galena occur in the cherty units of Cunningham Township as disseminations, thin concordant stringers that tend to be marginal to the cores of magnetite-rich laminae or beds, and as crosscutting veinlets and fracture-filling material. Galena may also be present as isolated scattered cubic crystals with sides up to 1 cm in length. Variable amounts of 1 or more among fine-grained pyrite and pyrrhotite are commonly associated with sphalerite and galena. Chalcopyrite was seen less frequently than sphalerite and galena, and is locally altered to azurite and malachite. The weathered surface of a sphalerite-rich outcrop located very close to, and to the east of the small lake at the very centre of

Photo 8. *Detail from same outcrop area of Photo 7 showing boulder of interbedded magnetitic ironstone-chert.*

Cunningham Township, is noted for stains and mottlings caused by a white soft substance believed to be zinc hydroxide. This outcrop is part of a small cherty unit which has attracted most of the past exploration activity (see "Economic Geology", Occurrence No. 17).

The cherty units in the Yarwood Lake area of Garnet Township extend for a short distance into Cunningham Township, and are poorly exposed east of Yarwood Lake. The largest of these units has an estimated maximum length and width of about 4000 and 170 m respectively. Small outcrops of ferruginous chert were found on the north side of the Wakami River at 2 localities, 1 in east-central Garnet Township, and the other about 460 m east of the western boundary of Benton Township. The locations of these outcrops, and the existence of a prominent northwestward trending aeromagnetic ridge which extends from the Yarwood Lake area of Garnet Township to central Benton Township (Ontario Department of Mines-Geological Survey of Canada 1963a, 1963b), suggest that the Yarwood Lake cherty units may extend intermittently to the southeast as far as western, or possibly central Benton Township.

The northwestward trending chert unit in the northeastern part of Benton Township is interbedded with tholeiitic basalt in the lower stratigraphic section of the metavolcanics of the map area, and is part of the southern limb of the Woman River Anticline (Goodwin 1965). The general area has a pronounced northwestward trending linear aeromagnetic pattern (Ontario Department of Mines-Geological Survey of Canada 1963b).

The presence of iron-sulphide-bearing graphitic shale in the swampy area east of the Woman River in northwestern Mallard Township is indicated by drilling records. No outcrops were found in the area. This and other similar occurrences reported by assessment work records in a few other localities of the map area, suggest that sulphide-bearing shale or graphitic shale may represent a subordinate lithologic type in unexposed units underlying parts of the map area.

Microscopic Description Of the 6 thin sections that were examined, 3 contain an estimated volume of 30 to 75 percent iron oxides as magnetite and subordinate hematite, and the remaining sections contain only accessory amounts of iron oxides. In all sections chert occurs as a cryptocrystalline to microcrystalline groundmass which tends to be very cloudy in appearance, and contains a minor clastic fraction consisting of a few quartz and feldspar particles up to 1 mm in size. These particles are affected by minute fractures many of which are stained or filled by iron oxides; the feldspathic particles are altered and probably albitic in composition. Acicular stilpnomelane microlites up to about 0.12 mm in length occur as an accessory component in the thin section of 1 of the magnetite-rich specimens (specimen 4-4-8). The chert of this specimen is partially recrystallized as indicated by local groundmass areas which are very fresh looking and consist of aggregates of equant quartz crystals up to 0.019 mm in size. Magnetite occurs dominantly as laminar aggregates but also as minute disseminations within the groundmass. Hematite is present in the form of diffuse red-brown to opaque stains which impart the cloudy character to the chert groundmass, and pyrite is apparently a rare accessory mineral.

No thin sections of sulphide-rich chert were examined.

FELSIC INTRUSIVE AND METAMORPHIC ROCKS

General Character

Granitic intrusions of significant size are found only in southwestern Cunningham Township and in northeastern Mallard Township. The granitic rocks in Cunningham Township are part of a relatively large pluton which is completely surrounded by supracrustal, gabbroic, and peridotitic rocks, and is bisected by a fault trending north-northwestward. The granitic rocks underlying northeastern Mallard Township are part of the regional granitic rocks, and are poorly exposed. Consequently, the geological boundary delimiting these rocks to the southwest is largely interpretive. Apart from the above, minor occurrences of granitic rocks are found also in metavolcanics or gabbro at a few other localities of Cunningham and Mallard Townships.

No differences were noted between the granitic rocks underlying southwestern Cunningham Township and northeastern Mallard Township. All these rocks are essentially massive, medium to coarse grained in texture, mostly pink in colour, and potassic in composition. Except for local areas where variably assimilated xenoliths of metavolcanics or gabbro are present, the granitic rocks are generally monotonous in appearance, and leucocratic in character. Some outcrops of (regional) granitic rocks locally found along the southwestern shore of Rush Lake (outside present map area), are trondhjemitic (i.e. sodic) in appearance, and contain scattered chalcopyrite crystals which are up to 8 mm in size, and are variably altered to malachite.

Microscopic Description

In a thin section of a sample of the granitic pluton in Cunningham Township (specimen 4-4-3), the approximate amounts of microcline, oligoclase (An_{21}), and quartz were found to be 45, 30, and 21 percent of the rock in volume, respectively. The accessory minerals account for the remaining 4 percent in volume, and include dominant biotite which is generally chloritized, sericite as an alteration product of feldspars, epidote (mostly in tiny fractures), muscovite microlites (in feldspars), hornblende relics, pyrite, iron oxides, and traces of apatite (?) and zircon (in biotite). The rock is not texturally homogeneous as about half of the crystals of the principal components have sizes of 0.9 to 2.6 mm, and the other half have an average size of about 0.12 mm. The quartz and feldspar crystals appear to be equally distributed in both these size-classes.

MIDDLE TO LATE PRECAMBRIAN (PROTEROZOIC)

FELSIC INTRUSIVE ROCKS

The age relationships among the Middle to Late Precambrian syenite, lamprophyre and diabase are uncertain. The only syenite dike that was found is located in southern Cunningham Township, intrudes mafic metavolcanics, and is assumed to represent a late stage of granitic intrusion.

Syenite is a massive porphyritic rock of red colour which consists of a fine-grained and texturally homogeneous groundmass, containing an estimated 2 percent in volume of prominent feldspathic and mafic phenocrysts. In thin section the groundmass of the rock is seen to consist of very altered feldspar/saussurite? crystals with average size of 0.09 mm, and to contain quartz and iron oxides in volumes of about 5 and 3 percent, respectively. The feldspathic phenocrysts represent about 0.7 percent of the rock in volume, and consist of laths of saussuritized plagioclase which are up to 13 mm in length. Saussuritization of plagioclase, in both the phenocrysts and the groundmass, is largely such that only the outlines of the (former) plagioclase crystals are recognizable. In the plagioclase crystals that are not thoroughly altered, saussurite is mostly found in the central parts of the crystals, but it may also be found, though rarely, in the peripheral areas of the crystals. The plagioclase is unidentified but the extent of alteration suggests that it is rather calcic in composition. The mafic phenocrysts are up to 2 mm in size, and thus are generally considerably smaller than the plagioclase phenocrysts. They consist dominantly of a thoroughly chloritized mineral which is probably clinopyroxene, and of a few flakes of chloritized biotite.

MAFIC INTRUSIVE ROCKS

A lamprophyre dikelet intrudes gabbro, which is regarded as time-equivalent with basalt, at 1 locality in central Cunningham Township; a similar dikelet intrudes granitic rocks in the southwestern part of the same township. On the basis of the present field evidence it is not known whether the intrusion of lamprophyre predated, accompanied, or postdated the intrusion of diabase.

Lamprophyre is a dense, fine- to medium-grained mafic rock, which has brownish green colour and is characterized by the conspicuous presence of black biotite books up to about 1 cm in size. The only dikelet of this rock seen by the writer has an exposed length of about 5 m, and maximum thickness of 63 cm.

Diabase is a massive medium- to coarse-grained rock, which is generally of dark green colour. It is locally porphyritic owing to the presence of saussuritized plagioclase phenocrysts which are greenish white in colour, and up to a few centimetres in size. Because of similarities in texture and colour index between (Late Precambrian) diabase and certain phases of gabbro (of older age), it is possible that some outcrops mapped as diabase are gabbro, and vice versa. Nevertheless, in the writer's opinion, diabase dikes are indeed rare within the map area. Seven diabase outcrops aligned in a west-northwest direction in Benton Township, are interpreted as discrete exposures of the same prominent dike which intrudes concordantly the metavolcanics. Concordant relationships of similar nature are also displayed by another large dike which trends northwestward, and is intruded along the contact of metavolcanic and granitic rocks in southeastern Mallard Township. In a thin section of a diabase sample from the main dike in Benton Township (specimen 4-18-6), plagioclase which is presumably andesine, interstitial clinopyroxene, and opaques, are seen to account for about 75, 20, and 5 percent respectively of the rock in volume. The opaque minerals consist of dominant skeletal ilmenite, a little leucoxene, and traces of pyrite. Owing to variably developed saussuritization and/or carbonatization of the plagioclase, this rock lacks the fresh-looking appearance which is commonly seen in thin sections of diabase.

Structural Geology

A general northwestward trend is characteristic of foliation in the mafic metavolcanics, and of layering and foliation in the intermediate and felsic metavolcanic units and in some of the smaller metasedimentary units. Dips are generally subvertical, or steep to the southwest.

Although the gabbroic intrusions are to some extent irregular in outline, some of the intrusions are elongated and trend northwest, and so do large parts of some other intrusions. Because of this, the writer suggests that the gabbroic intrusions are also largely concordant, and that their present planimetric outlines represent vertical cross sections of formerly horizontal sills which were tilted by folding to their present subvertical or steeply dipping attitude. This is consistent with the presence of the core of the eastward trending Woman River Anticline (Goodwin 1965) in Marion and Heenan Townships (adjacent to the northern boundary of the present map area). Thus, the metavolcanics and associated gabbroic intrusions underlying the present map area are interpeted as part of the southwestern limb of this anticline, which is regarded as a prominent structural feature in the southern part of the Swayze Belt. It was also previously suggested that the gabbroic rocks are of subvolcanic origin (see section "General Character" under "Mafic Intrusive Rocks"), and that gabbro and basalt are in broad terms time-equivalent. In the writer's opinion, each main intrusion of gabbro may be expected to be of about the same age as part of the basaltic sequence stratigraphically above it (i.e. to the southwest of it), and, therefore, the age range of the gabbroic intrusions considered together may be expected to be the same as the time span taken by volcanism to develop the sequence presently extending from northern Mallard Township (bottom) to southern Cunningham Township (top).

Among the northwestward to northeastward trending faults affecting the rocks of the map area, the prominent one is the fault which trends north-northwestward and bisects the granitic pluton in southwestern Cunningham Township. As a result of this fault, the eastern half of the pluton is displaced 1600 m north of the western half of it. More generally, the northward displacement of the eastern side is a characteristic feature displayed by several main northwestward trending faults affecting the Swayze Belt east and south of the present map area (Siragusa 1979; 1980).

Economic Geology

CUNNINGHAM TOWNSHIP

HISTORY OF MINERAL EXPLORATION

Unless otherwise specified, information in this section is from the Assessment Files Research Office and the Geoscience Data Centre Files, Ontario Geological Survey, Toronto.

Interest in the area was originally aroused by the presence of iron in chert and prospecting for iron was carried out in the period 1904 to 1907 by the Ridout Mining Company. Development ceased after the iron content was found to be too low at that time for economic mining. In 1972 galena and sphalerite veins were found in chert and since then the search for base metal deposits in chert has been apparently the main aim of the large volume of exploration work carried out in the township.

A property consisting of 12 claims in the Allen Lake area was acquired in 1933 by Swayze-Huycke Gold Mines Limited; diamond drilling was done in 1933 and shaft sinking began in 1934. By September of that year a complete mining plant had been installed and the 2-compartment shaft had reached a depth of 150 feet with a level at 125 feet. About 30 feet of drifting and 98 feet of crosscutting had been completed. This work revealed that promising surface gold values did not extend at depth and operations were suspended. In 1939 the property was sold to Olive Gold Mines Limited and in 1961 was restaked by Flint Rock Mines Limited.

Most of the exploration and development work done to date occurred on the property of Consolidated Shunsby Mines Limited located in the central part of the township. Exploration by different companies in other areas of the township included 1 or more of geological mapping, geophysical surveys, trenching, and drilling. Recorded data on drilling in these areas are summarized in Table 11 in chronological order.

In the summer of 1955, E. Sootheran and H. Paul found chalcopyrite and sphalerite in claim S34947 and optioned 20 claims to Shunsby Gold Mines Limited; in 1967 this name was changed to Consolidated Shunsby Mines Limited; in 1975 the company was renamed MW Resources Limited. During the period 1955 to 1957 Shunsby completed a program of geological mapping, stripping and trenching, and diamond drilling of 74 holes totalling 20,336 feet. Nipiron Mines Limited, under an option agreement with Shunsby, undertook further exploration in the winter of 1960 to 1961. A geological survey was made over part of the property; 9 holes totalling 3,605 feet were diamond drilled and an additional 15 claims were staked and transferred to Shunsby. In June and July of 1961, 9 holes totalling 4,110 feet were diamond drilled and a limited amount of magnetic and electromagnetic surveying was carried out. In 1965 financing was provided by the F.R. Joubin Prospecting Syndicate and an additional 14,279 feet of diamond drilling were completed. In August 1968 a prospectus was filed with the Ontario Securities Commission under which $100,000 were provided to the company through a public underwriting, and in the period October 1968 to February 1969 further drilling totalling 9,091 feet was completed. Thus, by February 1969 diamond drilling on the Consolidated Shunsby property totalled 51,417 feet. In 1970 a geological and geochemical survey was carried out over a group of claims in the western part of the property. As of August 1971 the property included 20 patented claims (the original Sootheran-Paul group), 1 licence of occupation over 23.32 acres, 10 leased claims, and 11 ordinary claims, all in 1 block. In the summer of 1974 Grandora Explorations Limited (now Dora Explorations Limited) acquired an option on the Consolidated Shunsby property under the terms of which Grandora must spend $250,000 on the property by August 31, 1978 (The Northern Miner 1974a). In December 1974 the Grandora property included 39 claims of the former Consolidated Shunsby property and 22 claims staked by Grandora on the western and southern boundaries of the optioned land (The Northern Miner 1974b). By January 1975 at least 2,871 feet of drilling had been completed by Grandora (The Northern Miner 1975a, 1975b), and by early July 1975 the expenditures of the company in Cunningham Township were $180,163 (The Northern Miner 1975c). In 1978, 5 drillholes for a total of 1,237 feet were completed by MW Resources Limited in the Beavertail Lake area.

TABLE 11. SUMMARY OF RECORDED INFORMATION ON DRILLING IN CUNNINGHAM TOWNSHIP BY OPERATORS OTHER THAN MW RESOURCES LIMITED.

Year	Company	Claim	No. of D.D.H.	Length in metres (feet)	
1923 1929	Ridout Cunningham Mines Ltd.	S 57672	?	?	?
1952	J.E. Derraugh & Maneast Uranium Corp. Ltd.	S 57671 S 57672	1 4	128.9 304.8	(423) (1000)
1953	Page-Harley Mines Ltd.	S 61030 S 61132 S 62785	7 1 1	648.4 117.6 141.1	(2127) (386) (463)
1954	The American Metal Co.	S 62655 S 62505 S 62503 S 58597	1 2 1 1	62.0 259.0 117.6 170.5	(203) (850) (386) (559)
1956	J.E. Derraugh & Maneast Uranium Corp. Ltd. J.M. MacIntosh Mid-North Engineering Ltd. Maneast Uranium Corp. Ltd.	S 57671 S 57670 S 57669 S 76342 S 90807 S 61137	1 1 1 13 6 3	121.9 45.7 121.9 168.9 109.7 158.2	(400) (150) (400) (554) (360) (519)
1959	Rio Tinto Canadian Expl. Ltd.	S 110814	2	149.0	(817)
1961	The Anaconda Company (Canada) Ltd.	S 110481	1	69.2	(227)
1966	The International Nickel Co. of Canada Ltd.	S 131033 S 131693	1 1	46.6 176.0	(153) (577)
1971	Dome Exploration (Canada) Ltd.	S 292429	1	107.0	(351)
1937	Dome Exploration (Canada) Ltd. Newman Drilling & Exploration	S 292435 S 342323	3 1	159.1 44.8	(522) (147)
1975	Cordilleran Engineering Ltd.	P 422500	1	73.6	(241)
1977	Granges Exploration Aktiebolag (March) Canadian Division	P 450703 P 442947	1 1	54.8 63.4	(180) (208)

TABLE 12. PROPERTIES IN CUNNINGHAM TOWNSHIP AS OF OCTOBER 15, 1978

Owner	Location	Claims
Brian, Scott B.	Centre of township	S101856
Cleland, P., and Lundy, F.H.	Extreme northeast part of township at Yarwood Lake	S971, S965
Granges Exploration Aktiebolag	North-northwest of Mink Lake	2 unpatented
Lacasse, Lucien	Southwest quadrant	16 unpatented
MacGregor, Allan R.	Adjacent to south shore of Peter Lake	S116466 to S116469
MW Resources Limited	Centre of township	S90411 to S90415, S57536 to S57544, S57585, S43946 to S43948, S34944 to S34947, S61828 to S61830, S147117, S147118, S121596 to S121598, 11 unpatented claims
Pellow, K.A., and Broughton, R.	1.2 km south of Santinaw Lake, 0.6 km south of Peter Lake	S18141, S3112
Texasgulf Ltd.	West-southwest of Beavertail Lake and 1.6 km northeast of Peter Lake	S57699 to S57671, S57914, S57915, 3 unpatented
Tuttle, Douglas	Centred 2.80 km north of Isiah Lake	24 unpatented
	North of Peter Lake	6 unpatented

Recorded information indicates that an area adjacent to, and to the west of, the present MW Resources Limited-Dora Explorations Limited property has also attracted exploration since the early 1950s (see Table 11, J.E. Derraugh and Maneast Uranium Corporation Limited 1952, 1956, and Page-Harley Mines Limited, 1953). In 1952 Page-Harley Mines Limited completed 18 holes for a total of 5,916 feet in this area. In 1975 Sigouin-Hussey Geophysics carried out electromagnetic and magnetometer surveys over a group of 24 contiguous claims located west of the MW Resources Limited-Dora Explorations Limited property and held under option agreement by Sicintine Mines Limited. Seven of these claims were covered by further geophysical work done by Texasgulf Incorporated in 1976.

OWNERSHIP STATUS

Properties with claims or with leasing rights to claims, either patented or unpatented and active as of October 15, 1978, are listed in Table 12 along with the numbers of the claims where available and their location. For a more accurate location the reader is referred to Ontario Geological Survey Preliminary Map P.2339 (Siragusa 1980b).

MINERAL OCCURRENCES

Unless stated to the contrary, all reference sources in this section on occurrences are from the Assessment Files Research Office, Ontario Geological Survey, Toronto. Occurrence numbers are located on Geological Map 2503 in the back pocket.

The mineral occurrences shown on Map 2503 include surface occurrences, and occurrences intersected by drilling carried out by mining companies at different times and in various localities of the map area. Although perusal of the records suggests that some of the occurrences found by drilling are of little economic significance, these are shown on the map because, particularly in areas of thick overburden, they represent the only available data on local geological features. Descriptive field notes are given below for the mineral occurrences visited or found during present mapping. For further information on mineral occurrences found by exploration drilling, the interested reader is referred to the original source referenced for each occurrence.

Occurrence No. 1

Sphalerite and galena disseminations and rare galena crystals up to 3 mm in size in a quartz vein which is 2 to 7 cm thick, cuts aphanitic tholeiitic basalt, strikes N54E, dips 40 degrees north, and has an exposed strike-length of about 1.4 m. A mineralized sample of this vein (specimen 4-3-8) analyzed 2.4 percent Zn, 0.61 percent Pb, and negligible values of copper and precious metals (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 2

The following data are a summary of information kindly made available to the writer by Mr. Allan R. MacGregor. The data refer to drilling (1965) of six holes, four of which intersected significant base metal mineralization.

Diamond-Drill Hole	No. Mineralized Sections Intersected	Width of Section in Metres	Average base metal (in %)
"Mac 1"	1	5.6	4.2 Zn 1.0 Pb
"Mac 2"	2	5.02	4.73 Zn 0.87 Pb
		2.92	3.65 Zn 0.74 Pb
"Mac 4"	1	2.93	1.29 Zn 0.40 Pb
"Mac 5"	3	2.56	1.27 Zn 0.29 Pb
		2.44	1.43 Zn 0.48 Pb
		3.05	1.43 Zn 0.38 Pb

Occurrence No. 3

The showing is found in a partially filled old pit about 5 by 8 m in size. Grey to black locally ferruginous chert which has bedding thickness of 7 to 30 cm, is interbedded with subordinate graphitic shale, strikes west, and dips 80 degrees south, is intermittently exposed at the foot of the western wall of the pit. Disseminations and local massive stringers of fine-grained sphalerite and lesser galena occur within the chert; galena is also present as a few cubic crystals up to 1 cm in size. A composite sample consisting of 14 chips of mineralized chert from different beds (specimen 4-3-79) analyzed as follows: Fe 3.5 percent, Zn 3.0 percent, Pb 1.9 percent, Cu 780 ppm, Ni 84 ppm, Au 1.028 gram/tonne (g/t), Ag 7.199 g/t (Geoscience Laboratories, Ontario Geological Survey, Toronto). It may be noted that the Zn and Pb contents are more or less in agreement with the data from the first 2 holes of Occurrence No. 2.

Occurrence No. 4

This occurrence is found in a very old trench which trends S20E, is about 12 m long, and has a width and depth of approximately 1.5 m and 25 to 40 cm, respectively. The occurrence consists of an outcrop of structureless chert exposed over an area of about 1 m^2, and containing an estimated 60 percent in volume of pyrite mostly as fine-grained massive domains. A sample of massive pyrite (specimen 4-2-1) analyzed 38.5 percent Fe, and negligible values of Zn, Cu, Pb, Ni, Au, and Ag (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 5

Reference: Drilling Report No. 10, DDH No. 3 (J.E. Derraugh, Maneast Uranium Corporation Limited 1952).

The above source reports "good sphalerite" and "fair chalcopyrite" in sections that are 1.79 m and 60 cm wide respectively.

Occurrence No. 6

Disseminations and thin massive stringers of fine-grained sphalerite with minor galena and rare specks of malachite are in a 3 cm thick layer of chert. The chert layer is part of iron formation consisting of interbedded chert-magnetite which has a westward strike, and dips 60 degrees south; several outcrops of iron formation of the type just mentioned are present in the general area which show evidence of considerable stripping and trenching. A sample of the mineralized chert layer (specimen 4-4-6) analyzed 5.18 percent Fe, 2.3 percent Zn, 0.82 percent Pb, 0.40 percent Cu, and 4.46 g/t Ag (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 7

Reference: Drilling Report No. 10, DDH MS1 (Maneast Uranium Corporation Limited 1956).

The above source reports "a little Zn, Pb, and Cu" in a section 7.62 m wide.

Occurrence No. 8

Reference: Drilling Report No. 27, DDH N1 (Newman Drilling Exploration 1973).

The above source states "section from 58 to 147 feet carries fair sphalerite + galena throughout".

Occurrence No. 9

Reference: Drilling Report No. 10, DDH MS3 (Maneast Uranium Corporation Limited 1956).

The above source only mentions Pb, Cu, and Zn in a section about 8 m wide. No other information on the mineralization was given.

Occurrence No. 10

Reference: Drilling Report No. 30, DDH No. 78/5 (MW Resources Limited 1978).

This source reports "heavy pyrrhotite and pyrite in both fine bands and fractures"; a 5 cm thick section of massive galena, and minor zinc are also mentioned.

Occurrences No. 11 and 12

Reference: Drilling Report No. 11, DDH No. 11 to No. 25 inclusive (Page-Harley Mines Limited 1953).

The above source indicates ubiquitous zinc and lead mineralization in the cherty units underlying the area. A 21 m section of DDH No. 21 is logged as "ore formation". Analyses of samples from this section show maximum zinc and lead contents of 2.98 and 0.68 percent, respectively.

Occurrence No. 13

Reference: Drilling Report No. 30, DDH No. 78/1 to 78/3 inclusive (MW Resources Limited 1978).

The source reports pyrite and graphite; fine-grained galena is mentioned in one hole (i.e. DDH No. 78/2). Minor amounts of sphalerite are also mentioned.

Occurrence No. 14

Reference: W. Heshka, Consolidated Shunsby Mines Limited, map at a scale of 1 inch to 200 feet of the Tower (north) Group, 1970. File 2-1743.

The above source shows a pyrite and copper occurrence in a trench across the western boundary of claim S90411.

Occurrence No. 15

Here there is a steep outcrop of chert breccia having an exposed area of about 90 m^2, striking N55E, dipping 70 degrees northwest, and conspicuously affected by ochraceous staining. Sulphide mineralization is widespread and consists of fine-grained pyrite, pyrrhotite, and chalcopyrite as disseminations, veinlets, and local replacements. The presence of chalcopyrite is particularly obvious in the lower rim of the outcrop where it has altered into malachite. Two samples of mineralized chert, one from a malachitic area on the western side of the outcrop (specimen 4-6-103/A), and the other from the eastern side of it (specimen 4-6-103/B) analyzed the following metal contents (Geoscience Laboratories, Ontario Geological Survey, Toronto):

Specimen Number	Fe (in %)	Cu (in %)	Zn (in %)	Pb (ppm)	Ni (ppm)	Ag (g/t)
4-6-103/A	11.1	3.3	0.75	210	88	15.08
4-6-103/B	13.4	3.0	0.09	210	110	14.39

Occurrence No. 16

Medium-bedded chert striking N15E and dipping 70 degrees west is intermittently exposed for a length of about 70 m along the eastern edge of a northward trending ridge. Fine-grained sphalerite, lesser galena, and rare malachite associated with variable amounts of iron sulphide minerals, occur as widespread disseminations, local thin massive stringers quasi-concordant to bedding, replacements, and fracture-filling material (in which case some quartz and/or calcite may also be present). Sphalerite mineralization is particularly abundant in an area of about 6 m^2 in the central part of the exposure; the weathered surface of the mineralized chert

in this area is characterized by patches and mottlings of a whitish soft dusty substance which is thought to be zinc hydroxide. A composite sample of mineralized chert from this part of the exposure (specimen 4-6-104) analyzed the following metal contents: Zn 5.46 percent, Fe 4.25 percent, Pb 0.51 percent, Cu 0.28 percent, Ag 9.94 g/t, Au 0.34 g/t (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 17

The triangular symbol at this location on Map 2503 in the back pocket is intended to represent a set of mineral occurrences which are in the general area indicated by the symbol, and cannot be shown individually at the present scale; most of the 15000 m of drilling done by Consolidated Shunsby Mines Limited prior to 1970 (see section on "History of Mineral Exploration") was concentrated in this area. This drilling indicated 1.1 million tons of 1.2 percent copper and 1.28 percent zinc (The Northern Miner 1974a). The most recent ore reserve figures known to the writer were reported (The Northern Miner 1975c) by Grandora Explorations Limited as an "indicated 1,000,000 tons amenable to open pit mining and 500,000 tons to underground methods", with "grades comparable to those indicated by the work of previous operators which was 1.2% copper and 1.28% zinc", and "in addition to this tonnage,...there is a potential 1,000,000 tons".

Occurrence No. 18

Reference: Drilling Report No. 20, DDH No. 3 (Consolidated Shunsby Mines Limited 1957).

The above source reports one or more among graphite, pyrrhotite, pyrite, and a little chalcopyrite and sphalerite in 4 sections of a 15 m deep hole. Presumably minor galena is reported in one of these sections.

Occurrence No. 19

Medium-bedded chert and brecciated chert striking N70W and dipping 83 degrees north are partially exposed at the bottom of a trench which trends N40W, is about 23 m long, 1.8 to 2.5 m wide, and 0.6 to 1.5 m deep. Brecciated chert is dominant in the northern end of the trench. Mineralization consists of fine-grained pyrite, pyrrhotite, and magnetite and occurs mostly as discrete massive domains up to 0.06 m^2 in size. During the brief time spent at this locality the writer was unable to ascertain whether mineralization is controlled by bedding or not; this is because of the intense ochraceous staining throughout the trench. At the south end of the trench the chert is truncated by the aphanitic chilled margin of an adjacent body of gabbro. A composite sample of massive iron sulphide mineralization and/or oxides from different domains of the outcrop (specimen 5-4-10) analyzed 38.7 percent Fe, and negligible values of Cu, Zn Pb, Ni, Au, and Ag (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 20

Reference: Drilling Report No. 14, DDH No. 54/305 (The American Metal Company Limited 1954).

The above source reports "heavy" pyrite, pyrrhotite, chalcopyrite mineralization in a 0.65 m wide section, and disseminations of the same sulphide minerals in another section about 1 m wide.

Occurrence No. 21

A small outcrop of ferruginous chert is interbedded with basalt and has an exposed area of about 0.92 m^2. The attitude of bedding is uncertain owing to the severe shearing affecting the outcrop. Mineralization consists of a few magnetite-rich laminae in the cherty domain of the outcrop. A sample of one of these laminae (specimen 5-5-2) analyzed 14.9 percent Fe and negligible values of other base and precious metals (Geoscience Laboratories, Ontario Geological Survey, Toronto).

The log of 1 of 2 drillholes in the immediate vicinity of this occurrence (see Drilling Report No. 9, DDH Sh/63/3, Consolidated Shunsby Mines Limited, 1964), reports massive pyrrhotite, pyrite, and chalcopyrite mineralization in a section of undefined width.

Occurrence No. 22

A small outcrop of severely strained ferruginous chert strikes N60E, dips 50 degrees north, and contains thin massive stringers of magnetite. A composite sample of magnetite stringers (specimen 5-5-3) analyzed 32.5 percent Fe, and 0.68 g/t gold (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 23

Reference: Drilling Report No. 19 DDH Sh/64/2 (Consolidated Shunsby Mines Limited 1964).

The above source reports massive pyrite, pyrrhotite (or pyrrhotite-pyrite), chalcopyrite mineralization in 6 sections of uncertain widths.

Occurrence No. 24

Reference: Drilling Report No. 19, DDH Sh/64/1 (Consolidated Shunsby Mines Limited 1964).

The above source reports massive pyrite, pyrrhotite, chalcopyrite mineralization in one section, and massive pyrite and pyrrhotite mineralization with traces of chalcopyrite in 2 other sections of uncertain widths.

Occurrences No. 25 to No. 27 Inclusive

Reference: Drilling Report No. 13, DDH 54/302, 54/303, and 54/304 (The American Metal Company Limited 1954).

The above sources report dominantly disseminated to locally massive pyrite-pyrrhotite mineralization in all the 3 holes; little to very little of one or more among chalcopyrite, sphalerite, and (rare) galena are also reported. Minor graphite is mentioned in the logs of 2 holes.

Occurrence No. 28

Reference: Drilling Report No. 26, DDH No. 27/3/1 (Dome Exploration (Canada) Limited 1971).

The above source reports 5 percent bands and stringers of pyrrhotite, pyrite, and/or graphite, with specks of chalcopyrite in a 4.66 m wide section of argillite. Analysis data for this section show 0.045 percent copper and traces of zinc. A section of peridotite at least 53 m wide was intersected at the bottom of this hole.

Occurrence No. 29

Reference: Drilling Report No. 26, DDH 27/3/2, 27/3/3, and 27/3/4 (Dome Exploration (Canada) Limited 1973).

The above sources report specks of chalcopyrite and sphalerite in disseminated to locally massive concentrations of one or more among fine-grained pyrite, pyrrhotite, and magnetite. The top 21 m of the section in hole 27/3/4 are logged as peridotite.

Occurrence No. 30

Reference: Drilling Report No. 18, DDH 2(11-1) and 3(11-2) (Rio Tinto Canadian Exploration Limited 1959).

The above sources report a graphitic zone with local pyrrhotite and pyrite mineralization and very minor chalcopyrite and sphalerite.

Occurrence No. 31

Reference: Drilling Report No. 28, DDH SW/33 (Granges Exploration Aktiebolag 1977).

The above source reports a 2.8 m wide section containing 20 percent pyrite and pyrrhotite. Graphite is also mentioned.

Occurrence No. 32

Reference: Drilling Report No. 29, DDH SW/31 (Granges Exploration Aktiebolag 1977).

The above source reports 30 percent pyrite and minor pyrrhotite in a 64 cm wide section.

Occurrence No. 33

Minor pyrite disseminations are in pillowed basalt. A sample of pyritized basalt (specimen 3-7-14) analyzed 8.63 percent Fe, and 0.34 g/t (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 34

Reference: Meen, V.B. (1944) Geology of the Cunningham-Garnet Area: Ontario Department of Mines, Annual Report for 1942, Volume 51, Part 7, 26p.

The only available data have already been presented in the "History of Mineral Exploration" at the beginning of the "Economic Geology" section. No other data were found in the Meen (1944) source nor in the assessment record on this former property of Olive Gold Mines Limited.

Occurrence No.35

Iron formation consisting of interbedded chert-magnetite striking westward, dipping subvertically, and intermittently exposed over an estimated area of 8000 m^2. A composite sample of magnetite layers from this locality (specimen 3-9-9) analyzed 28.1 percent Fe, and 7.54 g/t silver (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 36

Iron formation of undetermined attitude and of the same general type as Occurrence No. 35, is poorly exposed over an estimated area of 400 m^2. A composite sample of magnetic layers from this locality (specimen 3-8-8) analyzed 19.0 percent iron (Geoscience Laboratories, Ontario Geological Survey, Toronto).

GARNET TOWNSHIP

HISTORY OF MINERAL EXPLORATION

Unless otherwise specified, information is from the Assessment Files Research Office and the Geoscience Data Centre Files, Ontario Geological Survey, Toronto.

Garnet Township has attracted much less exploration activity than Cunningham Township. Recorded data show that a total of 4,465 feet of diamond drilling have been completed in the area as of November 1971. Data on this drilling are summarized in Table 13 in chronological order. The drilling locations are scattered and far apart with a few exceptions where drilling was aimed at checking interbedded chert-magnetite iron formation in the southwestern and northeastern parts of the township. In 1976 a northern strip of the township was covered by an airborne magnetometer survey done by Union Miniere Explorations and Mining Corporation Limited (UMEX). This survey covered all the Townships of Denyes, Dore, and Heenan, and parts of Rollo and adjacent townships.

TABLE 13. SUMMARY OF RECORDED INFORMATION ON DRILLING IN GARNET TOWNSHIP.

Year	Company	Claim	No. of D.D.H.	Length in metres
1957	CMS Syndicate	S 92518	1	22.8
		S 92519	1	12.2
		S 92515	1	27.4
1965	The International Nickel Co. of Canada Ltd.	S 131702	1	44.5
1966	The International Nickel Co. of Canada Ltd.	S 131037	1	133.2
		S 131891	1	289.3
		S 131898	2	289.5
		S 131052	1	122.5
		S 131056	1	104.2
		S 131698	1	107.6
1968	The International Nickel Co. of Canada Ltd.	S 152494	1	120.4
		S 152505	1	123.1
1971	Dome Exploration (Canada) Ltd.	S 292406	1	107.5

In the summer of 1977 no exploration activity was apparently done in Cunningham and Garnet Townships but some diamond drilling was being done in Benton Township

OWNERSHIP STATUS

Properties with claims or with leasing rights to claims, either patented or unpatented and active as of October 14, 1978, are listed in Table 14 along with the numbers of the claims where available and their location. For a more accurate location the reader is referred to Ontario Geological Survey Preliminary Map P.2340 (Siragusa 1980c).

MINERAL OCCURRENCES

Unless stated to the contrary all reference sources in this section on occurrences are from the Assessment Files Research Office, Ontario Geological Survey, Toronto. Occurrence numbers are located on Geological Map 2503 in the back pocket.

TABLE 14. PROPERTIES IN GARNET TOWNSHIP AS OF OCTOBER 15, 1978.

Owner	Location	Claims
Boddy, P., and Dobie, F.J.	1.6 km east of west boundary and 1.2 km south of north township boundary	S929
Cleland, P., and Lundy, F.H.	Northwest corner of township	S908, S909, S910, S913, S924 to S928

The mineral occurrences shown on Map 2503 include surface occurrences, and occurrences intersected by drilling carried out by mining companies at different times and in various localities of the map area. Although perusal of the records suggests that some of the occurrences found by drilling are of little economic significance, these were shown on the map because, particularly in areas of thick overburden, they represent the only available data on local geological features. Descriptive field notes are given below for the mineral occurrences visited or found during present mapping. For further information on mineral occurrences found by exploration drilling, the interested reader is referred to the original source referenced for each occurrence.

Occurrence No. 37

Westward trending and subvertical dipping iron formation in this occurrence consists of interbedded chert-magnetite. The exposure has an estimated width and length of 130 m and 350 m, respectively, and several old trenches and pits are found in the general area. The estimated average proportion of ironstone to chert is about 45 percent; minor pyrite disseminations and local concentrations of 1 to 2 percent are not uncommon in both the ironstone and the cherty domains of the formation. A sample of very fine grained massive magnetite from a layer about 45 cm thick (specimen 3-9-11) analyzed 32.0 percent iron (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 38

Iron formation of the same general type and structural attitude of Occurrence No. 37 is intermittently exposed in old trenches over a distance of about 60 m. The estimated ratio of ironstone to chert is 2:3. A sample of magnetite from a layer 14 cm thick (specimen 3-9-8) analyzed 30.2 percent iron (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrences No. 39 and No. 40

Reference: Drilling Report No. 14, DDH 31914, 31915 (The International Nickel Company of Canada Limited 1966).

This source reports iron formation (of unspecified type) in both holes and particularly in hole 31914.

Occurrence No. 41

Iron formation of the same general type of Occurrence No. 37 is exposed over an area of about 12 m^2, has an inferred northwest strike, dips 83 degrees north, contains magnetite layers 2 to 31 cm thick, and has an estimated ironstone to chert ratio of 3:7. A sample of a 4 cm thick magnetite layer (specimen 5-9-2-6) analyzed 38.9 percent iron and 0.34 g/t gold (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 42

Reference: Drilling Report No. 11, DDH No. 29131 (The International Nickel Company of Canada Limited 1965).

This source reports iron formation (of unspecified type), and (presumably minor) iron sulphides mineralization.

Occurrences No. 43 and No. 44

References: Drilling Report No.10, DDH No. 4 and No. 6 (CMS Syndicate 1957).

The log of hole No. 6 (Occurrence No. 43) reports a "fair amount of sulphides and a few specks of chalco" in a section 4.5 m wide, and that of hole No. 4 (Occurrence No. 44) reports "scattered fine chalco and pyrite" in a section about 8 m wide.

Occurrence No. 45

Iron formation at this location consists of (a) chert layers 1.5 to 30 cm thick interbedded with (b) layers of ironstone of similar thickness and variable magnetite content, and (c) layers of slate varying in thickness from less than 1 cm to about 1 m. The width and length of the exposure are about 9 m and 100 m, respectively; the inferred strike is northwest and the dips are subvertical. A composite sample of ironstone layers from this outcrop (specimen 5-11-2) analyzed 44.2 percent iron, negligible values of Cu, Zn, Pb, Ni, Au, Ag, 0.20 percent titanium dioxide, and 124 ppm chromium (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 46

Iron formation is of the same general type and with the same structural attitude of Occurrence No. 45. The width and length of the exposure are about 8 m and 30 m respectively, and the higher ironstone concentration is in a section of the formation about 3 m thick. A composite sample of magnetite layers from this section (specimen 5-11-1) analyzed 22.3 percent iron, negligible values of Cu, Zn, Pb, Ni, Au, Ag, 0.22 percent titanium dioxide, and 208 ppm chromium (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Occurrence No. 47

Reference: Drilling Report No. 16, DDH No. 31918 (The International Nickel Company of Canada Limited 1966.)

The above source reports a graphitic shear zone about 8 m wide.

Occurrence No. 48

Reference: Drilling Report No. 19, DDH 27 6 1 (Dome Exploration (Canada) Limited 1971).

The above source reports disseminated to banded pyrite-pyrrhotite mineralization in iron formation (of undefined type) and graphitic argillite. The best analysis values reported are 0.075 percent copper and 0.10 percent zinc.

Occurrence No. 49

Reference: Drilling Report No. 13 DDH No. 31913 (The International Nickel Company of Canada Limited 1966).

The above source reports a "carbonate and graphite" shear zone of undefined width.

Occurrence No. 50

Reference: Drilling Report No. 12, DDH No. 31912 (The International Nickel Company of Canada Limited 1966).

This source reports 3 graphitic shear zones of undefined widths.

Occurrence No. 51

A small outcrop of ferruginous chert contains some magnetite and an estimated total 4 percent pyrite as disseminations and thin massive stringers a few millimetres thick. The length and width of the exposure are about 5.5 m and 90 cm, respectively; the strike is N20W and the dip is uncertain. A sample of mineralized chert from this locality (specimen 4-13-7) analyzed 16.8 percent iron, negligible values of Cu, Zn, Pb, Au, Ag; 0.16 percent titanium dioxide, and 432 ppm chromium (Geoscience Laboratories, Ontario Geological Survey, Toronto).

BENTON TOWNSHIP

HISTORY OF MINERAL EXPLORATION

Unless otherwise specified, information is from the Assessment Files Research Office and the Geoscience Data Centre Files, Ontario Geological Survey, Toronto.

In the past, Benton Township has attracted less exploration activity than Mallard Township; there is little doubt that the poor access and the expanse of flat and swampy terrain over most of Benton Township have been negative factors. Recorded data on exploration other than drilling, and on drilling, are summarized in Tables 15 and 16 respectively.

During the summer of 1978 a crew of Noranda Exploration Limited was in the area. Drilling equipment was noted on the winter road leading west of Garnet Lake (Garnet Township) into Cunningham Township.

OWNERSHIP STATUS

Properties with claims or with leasing rights to claims, either patented or unpatented and active as of October 15, 1978, are listed in Table 17 along with the numbers of the claims where available and their location. For a more accurate location the reader is referred to Ontario Geological Survey Preliminary Map P.2341 (Siragusa 1980d).

MINERAL OCCURRENCES

Unless stated to the contrary all reference sources in this section on occurrences are from the Assessment Files Research Office, Ontario Geological Survey, Toronto. Occurrence numbers are located on Geological Map 2504 in the back pocket.

The mineral occurrences shown on Map 2504 were intersected by drilling carried out by mining companies at different times, and in various localities of the map area. Although perusal of the drilling logs suggests that most of these occurrences are of little economic interest, they are shown on the map because particularly in areas of thick overburden they represent the only available data on

TABLE 15. SUMMARY OF EXPLORATION WORK OTHER THAN DRILLING IN BENTON TOWNSHIP.

Year	Company	Surveys(*)	No. of claims in claim groups covered by surveys, and their general location in Tp.
1974/75	Noranda Exploration Co. Ltd.	M,EM	18 North-central
		M,EM	2 Southeastern
		M,EM	10 South-central
		M,EM	14 South-central
		M,EM	6 Northeastern
1975	U.S. Steel International Ltd.	EM,TMFG,G, RC,SC	15 North boundary

* Abbreviations:
M ground magnetic survey
EM ground electromagnetic survey
AM airborne magnetometer survey
TMFG total magnetic field gradient study
G geological mapping
RC rock geochemistry
SC soil geochemistry

TABLE 16. SUMMARY OF RECORDED DRILLING DATA IN BENTON TOWNSHIP.

Year	Company	Claim	No. of D.D.H. holes	Length in metres
1948/49	Blackstein & Kanowsky	S40249	9	338
		S40250	9	341
1976	W.G. Wahl Ltd.	P428954	1	152.4
		P428951	1	152.7
1977	Granges Exploration Aktiebolag	P451299	1	111.8
		P450979	1	104.8
		P450945	1	110
		P450952	1	79.5
1977	Noranda Exploration Co. Ltd.	P410863	1	137.7
1978	Granges Exploration Aktiebolag	P450931	1	62.2

local geological features. The salient data on mineralization are briefly summarized below; for further information the interested reader is referred to the original source referenced for each occurrence.

Occurrence No. 1

Reference: Drilling Report No. 13, DDH SW-39 (Granges Exploration Aktiebolag 1977).

The above source reports 1 to 5 percent pyrite and 15 to 20 percent graphite in 4 sections ranging in width from 1.52 to 52.7 m.

TABLE 17. PROPERTIES IN BENTON TOWNSHIP AS OF OCTOBER 15, 1978.

Owner	Location	Claims
Granges Exploration Aktiebolag	Bordering east shore of October Lake	1 unpatented
	Straddling the Wakami River approximately 2.5 km west of east township boundary and 0.8 km west of Woman River Junction	5 unpatented
Nelson Barry	West-central part of township straddling Wakami River, approximately 3 km east of township boundary	6 unpatented
W.G. Wahl Ltd.	Northeastern part of township	2 unpatented

Occurrence No. 2

Reference: Drilling Report No. 12, DDH SW-44 (Granges Exploration Aktiebolag 1977).

The above source reports 10 to 20 percent graphite in 6 sections ranging in width from 27 to about 9 m. In 1 of these sections, 1 to 2 percent pyrite is reported.

Occurrence No. 3

Reference: Drilling Report No. 15, DDH SW-38 (Granges Exploration Aktiebolag 1977).

The above source reports 10 to 15 percent graphite, and 1 to 5 percent pyrite and/or pyrrhotite in 6 sections ranging in width from 48 cm to 6.3 m.

Occurrence No. 4

Reference: Drilling Report No. 12, DDH SW-40 (Granges Exploration Aktiebolag 1977).

The above source reports 15 to 20 percent graphite in 7 sections ranging in width from 10 to 61 cm; 10 percent pyrite is reported in another section 1.34 m wide.

Occurrence No. 5

Reference: Drilling Report No. 16, DDH SW-50 (Granges Exploration Aktiebolag 1978).

The above source reports up to 10 percent pyrrhotite and/or pyrite in 3 sections ranging in width from 15 to 91 cm.

MALLARD TOWNSHIP

HISTORY OF MINERAL EXPLORATION

Unless otherwise specified, information is from the Assessment Files Research Office and the Geoscience Data Centre Files, Ontario Geological Survey, Toronto.

In 1933 Mallard Township was actively prospected for gold. Woman River Gold Mines Limited held a group of 14 claims which were staked in 1931 following the discovery of gold values in a shear zone located in the northwestern part of the township. These claims were surveyed in 1933, and development work consisted of a series of test pits and shallow trenches which exposed the shear zone for a length of 40 m with an average width of 3 m, and lesser trenching in other parts of the property. Presumably some trenching was carried out on this property also during the following year. Gold occurrences were also found in 3 other properties one of which, known as the Ferland-Gauldie-Mogridge claims, was located in central Mallard Township adjacent to the eastern bank of the Opeepeesway River. This property consisted of 18 claims in which stripping and trenching exposed a shear zone for a length of about 140 m, and a width ranging from 5 to 10 m. In September of 1933 N.A. Timmins Corporation optioned the claims, completed 4 diamond-drill holes for a total of 150 m, and subsequently dropped the option in 1934. The other 2 properties consisted of 2 groups of claims known as the Hermiston-Hammerstrom claims and the Maltby claims, which were located adjacent to and west of the Ferland-Gauldie-Mogridge claims, and within a short distance southeast of the latter, respectively. An unspecified, although presumably small, amount of stripping and trenching was apparently the only development work carried out on these 2 properties. From the geological descriptions of the above properties (Laird 1936), it is apparent that quartz veins in sheared and silicified volcanic rocks and the presence of small bodies of "porphyry" or "felsite" (i.e. subjacent felsic volcanic rocks) are the favourable environment for gold mineralization in Mallard Township.

In more recent times the emphasis of exploration has shifted toward search for base metal deposits. Following the discovery of copper in southwestern Genoa

TABLE 18. SUMMARY OF EXPLORATION WORK OTHER THAN DRILLING IN MALLARD TOWNSHIP.

Year	Company	Surveys(*)	No. of claims in claim groups covered by surveys, and their general location in Tp.
1970/71	Bulldog Mines Ltd.	M.EM.G	12 South-central
1970/71	Panacea Mining and Exploration Ltd.	M.EM	12 Northeastern
1972	Claw Lake Mines Ltd.	AM	39 Northern
1975	Noranda Exploration Company Ltd.	M.EM	8 Southern
1975/76	U.S. Steel International Ltd.	EM.TMFG.G. RC.SC	15 Northwestern
1977	Noranda Exploration Company Ltd.	M.EM	4 Southern

* Abbreviations:
M ground magnetic survey
EM ground electromagnetic survey
AM airborne magnetometer survey
TMFG total magnetic field gradient study
G geological mapping
RC rock geochemistry
SC soil geochemistry

Township (The Northern Miner 1970) which adjoins Mallard Township to the north, a staking rush occurred in Mallard Township. Recorded data on exploration other than drilling and on drilling are summarized in chronological order in Tables 18 and 19 respectively.

TABLE 19. SUMMARY OF RECORDED DRILLING DATA IN MALLARD TOWNSHIP

Year	Company	Claim	No. of D.D.H.	Length in metres
1933	N.A. Timmins Corp.	S24797	2	153
		S24799	2	?
1963	Anaconda American Brass Ltd.	S118285	1	120.7
		S118287	2	169.4
		S118291	8	959.8
1976	Gulf Canada Minerals Ltd.	P451699	1	151.7
		P451691	1	151.4
1976	W.G. Wahl Ltd.	P428943	1	145.3
		P428944	1	111.3

TABLE 20. PROPERTIES IN MALLARD TOWNSHIP AS OF OCTOBER 15, 1978.

Owner	Location	Claims
Goldman, Harry	Central part of township straddling and east of Opeepeesway River, 4.2 km north of south township boundary	S37427 to S37434, S53388, S24797 to S24800
Gulf Minerals Canada Ltd.	Straddling Opeepeesway River centred 2.6 km north of south township boundary	13 unpatented
Noranda Exploration Company Ltd.	0.4 km north of south township boundary, just east of Satterly Lake	2 unpatented
W.G. Wahl Ltd.	Northwestern part or township, east of Woman River	11 unpatented

OWNERSHIP STATUS

Properties with claims or with leasing rights to claims, either patented or unpatented and active as of October 15, 1978, are listed in Table 20 along with the numbers of the claims where available and their location. For a more accurate location the reader is referred to Ontario Geological Survey Preliminary Map P.2342 (Siragusa 1980e).

MINERAL OCURRENCES

Unless stated to the contrary all reference sources in this section on occurrences are from the Assessment Files Research Office, Ontario Geological Survey, Toronto. Occurrence numbers are located on Geological Map 2504 in the back pocket.

The mineral occurrences shown on Map 2504 were intersected by drilling carried out by mining companies at different times, and in various localities of the map area. Although perusal of the drilling logs suggests that most of these occurrences are of little economic interest, they are shown on the map because,particularly in areas of thick overburden, they represent the only available data on local geological features. The salient data on mineralization are briefly summarized below; for further information the interested reader is referred to the original source referenced for each occurrence.

Occurrence No. 6

Reference: Drilling Report No. 11, DDH WR8-76 (W.G. Wahl Limited 1976).

The above source reports several sections of "magnetite tuffite", and a 60 cm wide section of massive pyrite with possible minor sphalerite.

Occurrence No. 7

Reference: Drilling Report No. 12, DDH WR7-76 (W.G. Wahl Limited 1976).

This source reports "lean iron formation" of the interbedded chert-magnetite type. Some graphite and 1 to 3 percent pyrite are also reported.

Occurrence No. 8

Reference: Drilling Report No. 10, DDH F-5 and F-9 (Anaconda American Brass Limited 1963).

Graphite "threads" and ubiquitous pyrite-pyrrhotite disseminations are reported in DDH F-5; a 10 m wide section with 10 percent pyrite and pyrrhotite "with occasional grains of questionable chalcopyrite" is reported in DDH F-9.

Occurrence No. 9

Reference: Drilling Report No. 9, DDH F-1, F-2, F-3, F-4, F-6, F-8, F-10, F-11 (Anaconda American Brass Limited 1963).

The above source reports minor to significant graphite occurrences, and widespread dissemination of pyrite and/or pyrrhotite; specks of 1 or more among chalcopyrite, sphalerite, and (rare) galena are present within the iron sulphide minerals. The log of DDH F-6 reports a 40 cm thick section containing 10 percent chalcopyrite.

Occurrence No. 10

Reference: Drilling Report No. 10, DDH F-7 (Anaconda American Brass Limited 1963).

The above source reports minor and locally significant graphite occurrences, and widespread disseminations of pyrite and pyrrhotite.

Occurrence No. 11

Reference: H.C. Rickaby (1935) Geology of the Swayze Gold Area; Ontario Department of Mines Annual Report for 1934, Volume 43, Part 3, 36p.

Rickaby (1935, p.36) reports that a grab sample collected by him on this former property of Woman River Syndiate "assayed 0.34 ounces per ton in gold."

Occurrence No. 12

Reference: H.C. Laird (1936) Geology of the Opeepeesway Lake Area; Ontario Department of Mines Annual Report for 1935, Volume 44, Part, 7, p.1-30.

With reference to the drilling done in 1933 by N.A. Timmins Corporation in this former Gauldie-Mogridge property (see "History of Mineral Exploration"), Laird (1936, p.25) states: "The best results were obtained in No. 1 location, where one 10-foot section yielded an average of 0.11 ounces in gold per ton. Selected grab samples of well-mineralized schist from the surface yielded from 0.01 to 0.11 ounces gold per ton and from 1.45 to 4.85 ounces silver per ton."

Occurrence No. 13

Reference: H.C. Rickaby (1935) Geology of the Swayze Gold Area; Ontario Department of Mines Annual Report for 1934, Volume 43, Part 3, 36p.

Rickaby (1935, p.36) reports that grab samples collected by him at this locality of the former Gauldie-Mogridge property assayed up to "0.45 ounces per ton in gold". Rickaby (1935, p.36) reports also gold values of "0.21 and 0.28 ounces per ton in gold" in 2 grab samples collected by him "Near the east side of claim S. 24,851...": the location of this occurrence is within the former Hermiston-Hammerstrom property (see "History of Mineral Exploration"), and is described by Rickaby (1935, p.36) as being "Half a mile west of the Mogridge discovery..."

in the cherty units of Cunningham Township where most exploration work was done, minor disseminations to locally significant concentrations of base metal sulphide mineralization associated with pyrite and/or pyrrhotite, are of ubiquitous occurrence. In a few localities it was noted that sulphide mineralization becomes more conspicuous close to, or at the very interface with intrusive gabbro, and tends to decrease or disappear as one moves away from the contact toward the intrusive rock. Prospectors who had made similar observations and were met by the writer, expressed the opinion that the closer one is to contacts with mafic intrusive rocks, the greater are the probabilities of finding base metal sulphide mineralization. Also, judging from some drilling data, it seems reasonable to assume that this concept was to some extent expanded so as to regard the intrusive rocks themselves as potential hosts of base metals. For example, Sage (Thurston, Siragusa, and Sage 1977, p.235) reports that in the (former) property of Consolidated Shunsby Mines Limited (see Occurrence No. 17, Cunningham Township), "The lowest unit of the sequence is a massive, relatively homogeneous, fresh, fine- to medium-grained diorite which may represent an intrusion or very thick flow. This unit is referred to as the "Footwall Diorite" by Consolidated Shunsby Mines Limited. Drilling by Consolidated Shunsby Mines Limited has penetrated several hundred feet of this unit without encountering a lower contact".

Assuming that proximity to bodies of gabbro (or diorite) has been a leading concept in prospecting of the cherty units, and that parts of the intrusive bodies themselves have indeed been regarded as potential hosts of base metals, the present writer wishes to point out that caution should be used when applying both these concepts to exploration. In fact, although intrusion of mafic rocks appears to have locally resulted in concentration of sulphide mineralization in the contact zones, the presence of intrusive rocks, and particularly of large volumes of them, is in itself a negative factor. This is because these rocks intrude and disrupt the cherty units which host the base metals. The opinion held by the writer is that the chert-ironstone units of the map area should be prospected for base metals regardless of the presence of, or proximity to gabbroic or dioritic intrusions. For example, the chert-ironstone units of the Yarwood Lake area (northeastern Cunningham and northwestern Garnet Townships) seem to deserve more interest than they have apparently received thus far. Pending the correctness of the writer's structural interpretation of the general area (see section on "Structural Geology"), the Yarwood Lake units are stratigraphically below the chert-ironstone units in central Cunningham Township, and above those tracing the Woman River Anticline in Heenan, Marion, and Genoa Townships (Goodwin 1965). As base metal sulphide minerals occur in the chert-ironstone units in central Cunningham and northern Genoa Townships (Goodwin 1965, p.51; Sage *in* Thurston *et al.* 1977, p.240), no considerations of general stratigraphic nature speak against the possibility of base metal concentrations of economic interest in the Yarwood Lake units. If anything, the fact that these units are along strike of the main unit of calc-alkaline pyroclastic metavolcanics partially exposed in southern Mallard Township, may represent an additional favourable condition.

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